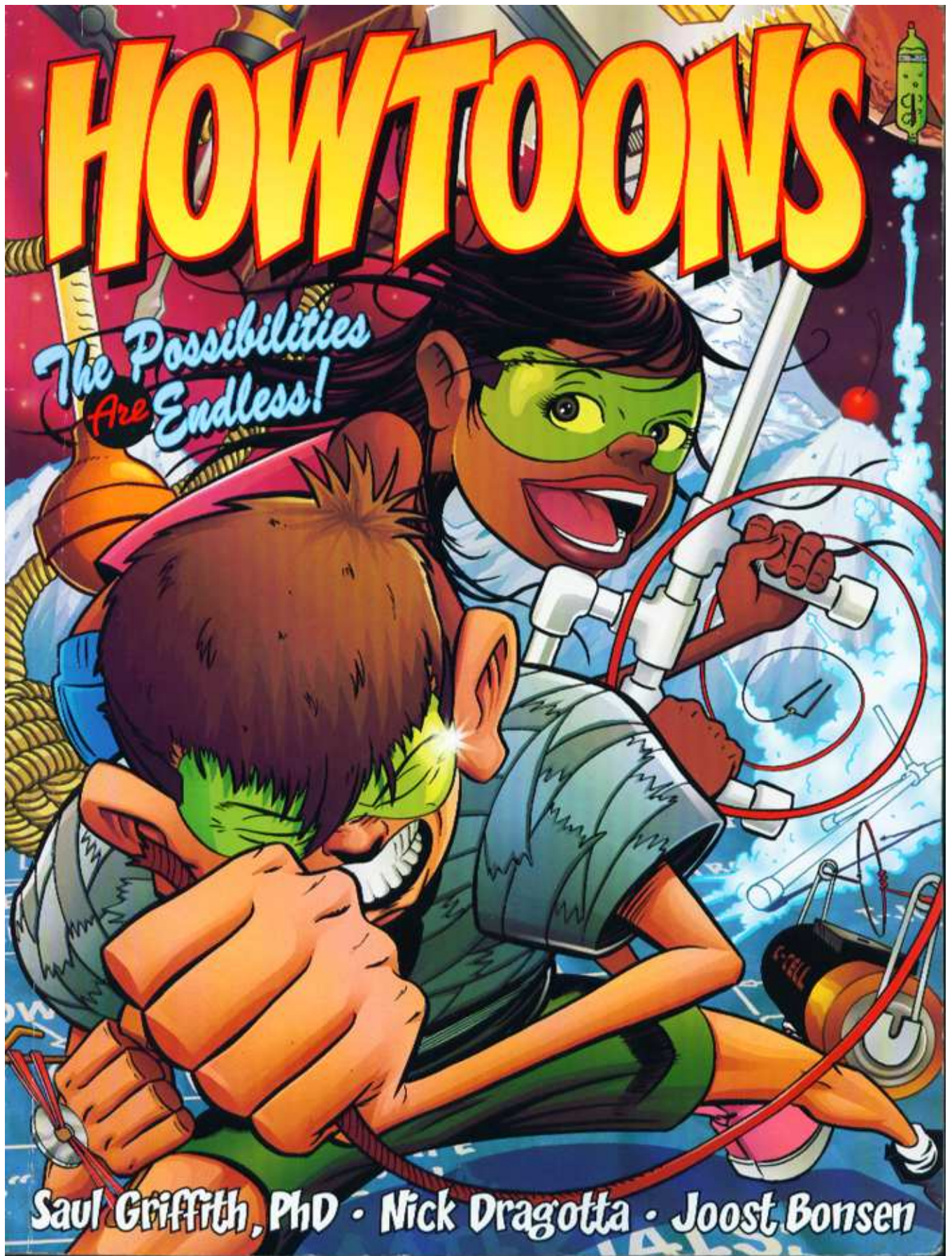


HOWTOONS

*The Possibilities
Are Endless!*



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AS A RESULT OF
FOLLOWING THE INSTRUCTIONS
CONTAINED IN THIS BOOK.



PLEASE NOTE:
THE AUTHORS & PUBLISHER RECOMMEND
ADULT SUPERVISION
ON ALL PROJECTS!

I N A SMALL AND BEAUTIFUL GALAXY,



ON A WONDERFUL LITTLE PLANET...



STIRRING IN THE QUIET STREETS
OF EVERYVILLE, A SMALL SUBURB
SURROUNDED BY OTHER
E'VILLES BY DIFFERENT NAMES,
SOMETHING WAS ABOUT TO HAPPEN...



SOMETHING IMPORTANT:



MISCHIEF AND INGENUITY...



...WOULD CONSPIRE...

...AS THEY OFTEN DO...



LEADING TWO SLIGHTLY UNUSUAL
KIDS INTO A WILD WORLD OF
INVENTION AND ADVENTURE!





HOWTOONS

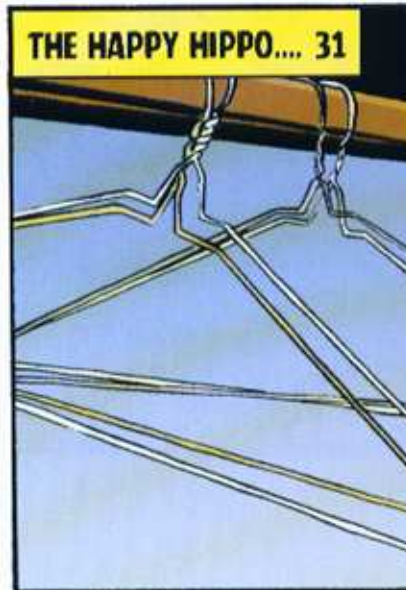
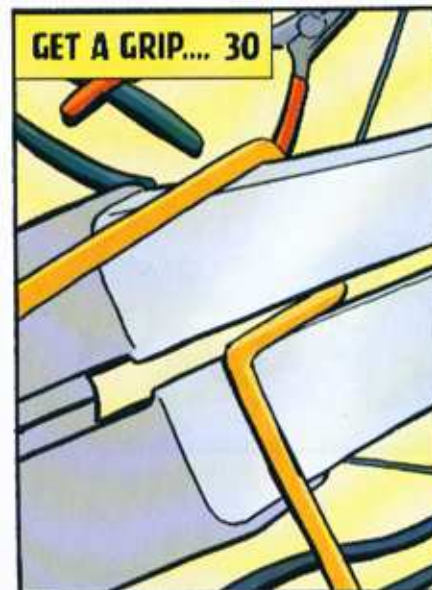
THE POSSIBILITIES ARE ENDLESS!



Collins

An Imprint of HarperCollins Publishers

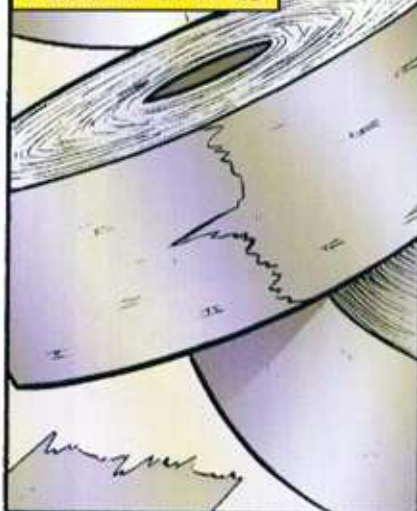




TERRARIUM.... 37



IT'S TIME TO PUMP IT UP.... 43



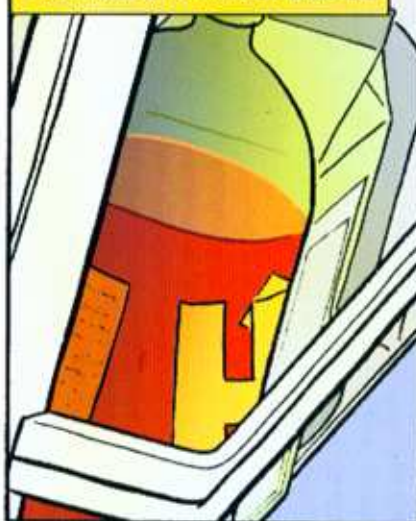
BIT BY BIT.... 49



LEGEND OF THE MONKEY FIST CLAN.... 53



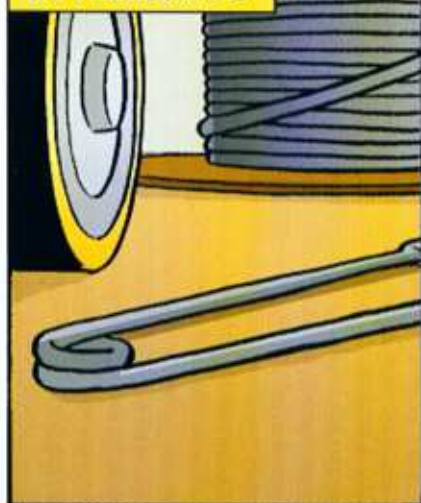
UNDERWATER SCOPE.... 66



FOR THOSE ABOUT TO ROCK.... 68



A NEW SPIN ON THINGS.... 76



THE RIGHTEOUS STUFF.... 79



GLOSSARY.... 100

HOW, *adverb*.
A manner or method of doing something.
"The how of research is generated by the why of the world!"

TOON, *noun. informal*.
A drawing depicting a situation, often accompanied by a word balloon or caption.

THE WORKSHOP




Yo!
Look at all the
cool stuff we can
build with a
workshop!


NEED TO DO OTHER THAN
TROUBLE!



NASA Engineer Lonnie
Johnson invented the
world's most powerful water
gun, the Super Soaker.




Sir Lawrence Hargreaves
designed the first box kites,
giving a lift to early aviation,
even using them to tow
small boats.



Mary Anning carried her
workshop with her. With her
geologist's tools, she discovered
the first plesiosaurus fossil.



America's first female astronomy
professor, Maria Mitchell, insisted her
students do real research, instead
of just learning from books.



George Washington Carver didn't
invent the peanut,
but did find thousands
of uses for them.



James Smith's
& MacMillan
first pedal
bicycle.

A detailed illustration of a cluttered workshop. In the upper right, a laptop displays a website with a large 'H' logo. To its left are two small boxes labeled 'MOZART' and 'FLOYD'. The central workbench is covered with various tools including a screwdriver, pliers, a saw, a light bulb, and a green balloon. A CD is also visible. In the foreground, a wooden workbench holds a vise with a piece of wood clamped in it. The floor is covered with wood scraps, a blue water bottle, and other debris. A large, dark diagonal beam crosses the scene from the top left to the bottom right.

A MUSEUM OF YOUR MOST FANTASTIC FAILURES AND TREMENDOUS TRIUMPHS!

ORGANIZE YOUR SPACE! MAKE YOUR MAKING EASY, SAFE, FUN AND PRODUCTIVE. ALWAYS BE PREPARED FOR THAT NEW PROJECT.

BUT...DON'T LET IT GET TOO CLEAN — YOU'LL WANT TO FEEL FREE TO MAKE A MESS. OOH, AND HOW YOU WILL WANT TO MAKE SOME TERRIBLE MESSSES.

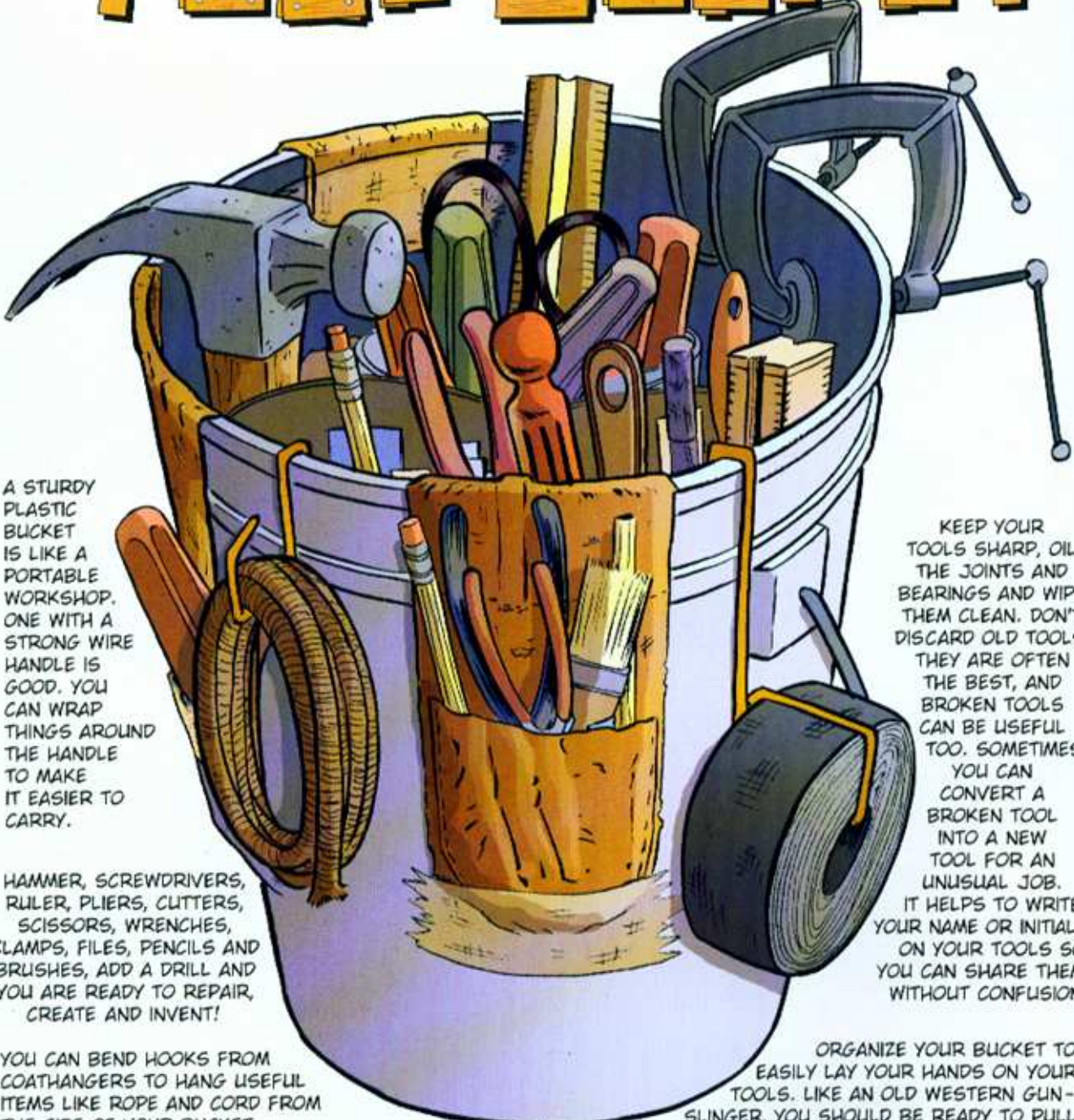


THERE ARE MANY, MANY, MANY
PROJECTS TO UNDERTAKE...

...AND IN THE CRACKS OF THOSE PROJECTS
AND BENEATH THE FILTHY UNDERBELLY OF YOUR
LATEST FRUSTRATION IS SOMETHING SPECIAL...

...YOUR LATEST INVENTION!

ANATOMY OF A TOOL BUCKET



A STURDY PLASTIC BUCKET IS LIKE A PORTABLE WORKSHOP. ONE WITH A STRONG WIRE HANDLE IS GOOD. YOU CAN WRAP THINGS AROUND THE HANDLE TO MAKE IT EASIER TO CARRY.

HAMMER, SCREWDRIVERS, RULER, PLIERS, CUTTERS, SCISSORS, WRENCHES, CLAMPS, FILES, PENCILS AND BRUSHES, ADD A DRILL AND YOU ARE READY TO REPAIR, CREATE AND INVENT!

YOU CAN BEND HOOKS FROM COATHANGERS TO HANG USEFUL ITEMS LIKE ROPE AND CORD FROM THE SIDE OF YOUR BUCKET.

ALWAYS KEEP A ROLL OF DUCT TAPE AND A ROLL OF WIRE HANDY.

KEEP YOUR TOOLS SHARP, OIL THE JOINTS AND BEARINGS AND WIPE THEM CLEAN. DON'T DISCARD OLD TOOLS, THEY ARE OFTEN THE BEST, AND BROKEN TOOLS CAN BE USEFUL TOO. SOMETIMES YOU CAN CONVERT A BROKEN TOOL INTO A NEW TOOL FOR AN UNUSUAL JOB.

IT HELPS TO WRITE YOUR NAME OR INITIALS ON YOUR TOOLS SO YOU CAN SHARE THEM WITHOUT CONFUSION.

ORGANIZE YOUR BUCKET TO EASILY LAY YOUR HANDS ON YOUR TOOLS. LIKE AN OLD WESTERN GUN-SLINGER, YOU SHOULD BE READY TO PULL THE PERFECT TOOL FOR THE JOB AT THE RIGHT MOMENT AS A MERE REFLEX. OLD JARS OR THE BOTTOM HALF OF SODA BOTTLES CAN BE USED TO SORT THE TOOLS INSIDE THE BUCKET.

A TALE OF THE INVENTION OF EVERYONE'S FAVORITE DESSERT...

CHOCOLATE TRIP ICE DREAMS

SOME SAY ICE CREAM WAS INVENTED IN
ANCIENT MONGOLIA! MAKES SENSE...

BRRR...I'M
FREEZING!

ME
TOO!



A LONG TIME AGO, IN AN ERA
OF EMPERORS AND KINGS...

TWO TRADERS
TREKKED HOMEWARD
AFTER A VERY
SUCCESSFUL
TRIP...



I hope the
king is pleased
with our *bonanza*
of goods.

How
could he *not* be
delighted?



THE TRAVELERS' MULE
WAS PACKED WITH GOODS
FROM THE FOUR CORNERS
OF THE GLOBE.



FROM THE WEST
AFRICAN TRADING
CITY OF TIMBUKTU
THEY PURCHASED
SALT MINED IN MALI AND
SHIPPED ACROSS THE
DESERT BY CAMEL -
AT THE TIME SALT WAS
WORTH ITS WEIGHT
IN GOLD!





ALL THE INGREDIENTS WERE STORED IN THE CLAY POTS AND SADDLE BAGS ATOP THEIR TRUSTY MULE AS THEY MADE THEIR WAY HOME OVER THE HIMALAYAS...

Careful!
The rocks are loose.

AND THEN... IT HAPPENED...

THE MOUNTAIN GAVE WAY AND OUR ADVENTURERS WENT A-TUMBLING!

THE HARD-WON GOODS OF THEIR ODYSSEY FLEW IN ALL DIRECTIONS!



A CLAY URN OF SALT
CRACKED INTO THE
HESSIAN SACKS
OF ICE.



THE POTS OF SUGAR,
VANILLA BEAN, CREAM,
MILK AND SPICES ALL
BROKE INTO ANOTHER
SADDLE BAG.



AND BY DIVINE FATE
THAT SADDLE
BAG FELL UPON
THE OPEN SACK OF
SALT AND ICE!



THE TWO GREAT EXPLORERS SAW
THEIR INGREDIENTS FREEZE
QUICKLY IN THE
SALT AND ICE MIX.



Hey! All of
the goods mixed
up and made that
giant mound of
ice and cream.

With a
cherry on
top!

MANY OF THE WORLD'S GREATEST
CREATIONS WERE BROUGHT
ABOUT BY THE CAREFUL AND
ENLIGHTENED OBSERVATION OF
AN ACCIDENT!



Mmmm.
Creamy-ice.
Smooth and
delicious!

The
king will be
pleased.

Provided
you don't eat
it all.



So that's it?
That was the discovery
of ice cream?

Yup, and it's
taken scientists
hundreds of years to
figure out how
it works.

The
secret is in the
thermodynamics! —
How quickly we
freeze the
ingredients.

After mixing
the components
thoroughly, we
pour them in our
first bag.

It's
important to
squeeze all the
air out.

Why?

Because still air is
an insulator and heat
doesn't pass through it.

That's why we use
double-pane windows
to keep the heat in.

To freeze our ice cream
the fastest, we don't
want anything insulating
our ingredients.



We need a second bag, a super freezer, to freeze the ingredients in the first bag.

The salt and ice combine to make a solution colder than the freezing point of ordinary water.

In fact, a salt-ice solution can remain a liquid to as low as -21.2°C or minus -6° F.

Now we put bag one, the ingredients bag, inside bag two, the freezer, and seal it tight!

I need gloves!

The freezer bag is sucking out my heat!

Now we just toss the bags for about 20 minutes until the ice cream ingredients are firm.

That's it! Open up the ingredients bag and serve! Enjoy!

So Tuck... what do you think?

Delicious!

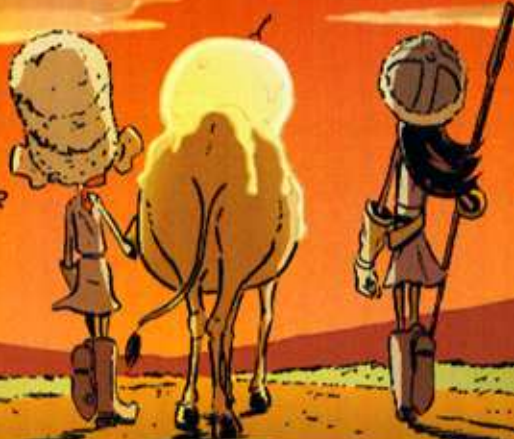
N

OBODY KNOWS THE EXACT ORIGINS OF WHAT WE KNOW TODAY AS ICE CREAM. IN FACT, MANY CULTURES DEVELOPED SIMILAR ICE-BASED DESSERTS: SORBET, SHERBET, KULFI, GELATI, SNO-CONES AND ICE CREAM.



A

LL THAT IS REALLY KNOWN IS THAT IT TOOK MANY ADVENTURES TO SCOUR THE WORLD FOR THE INGREDIENTS...



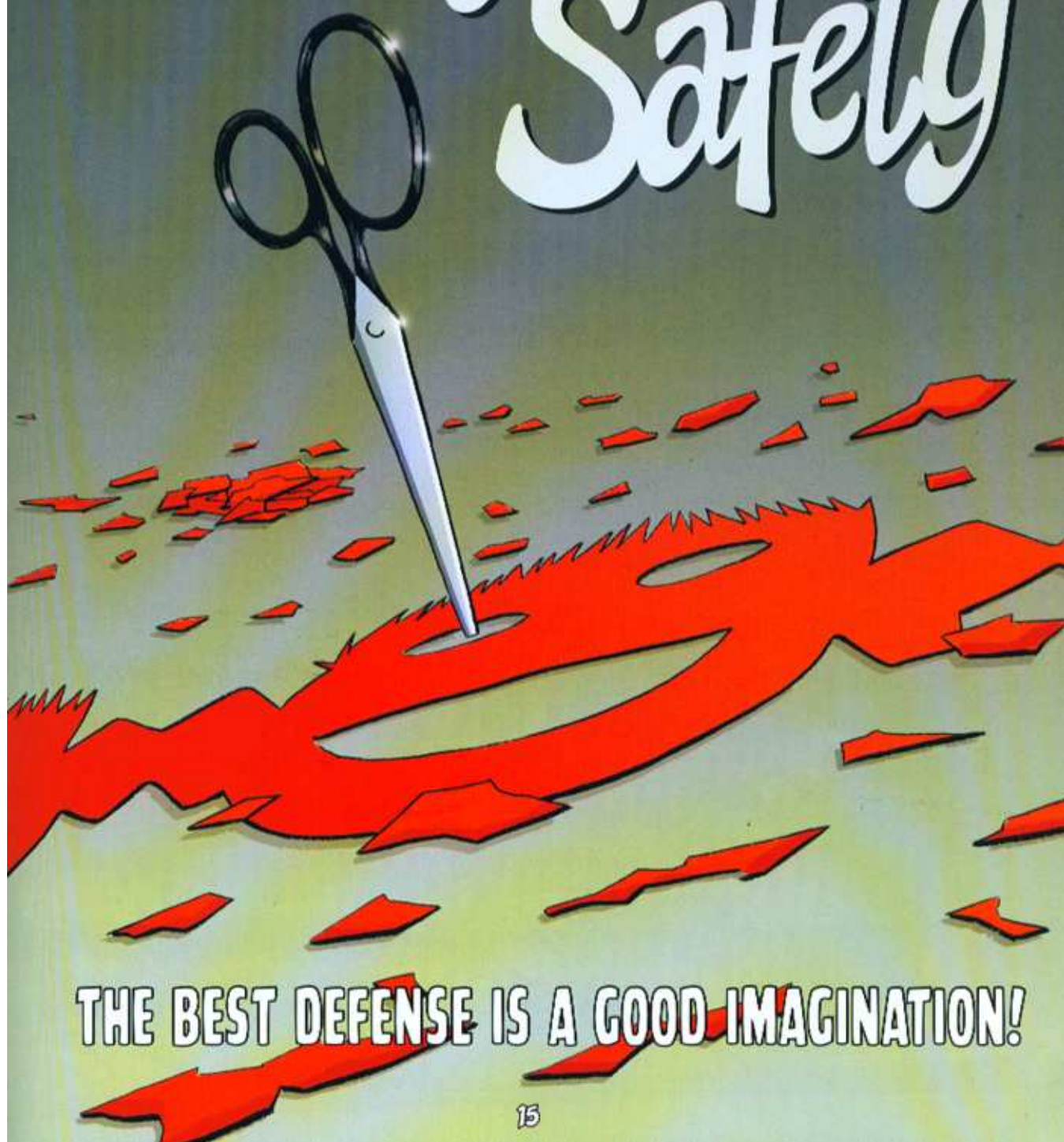
...AND A FEW EXPERIMENTALIST CHEFS TO CONVERT THEM INTO DOLLOPS OF DELIGHT!

Hey...
uh... Celine! Do you
want to take another
ice cream
break?

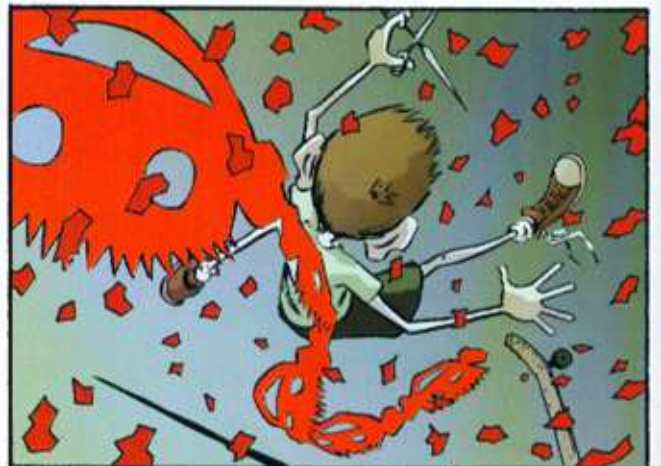


The
End!

An Eye for Safety



THE BEST DEFENSE IS A GOOD IMAGINATION!



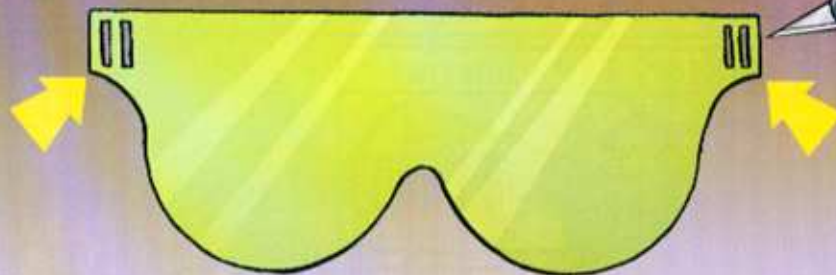








Use a sharp hobby knife to make two slits in each of the corners of the mask. Cut carefully! This part is tricky.

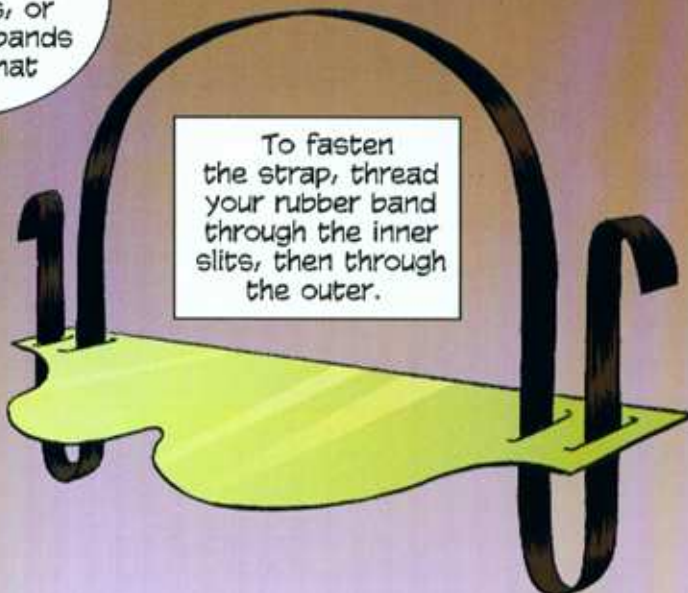


Last, you'll need straps to hold the mask on your face. Slitting an old bike inner tube into strips, or knotting rubber bands will give you what you need.



Use a lark's head knot to connect the rubber bands.

To fasten the strap, thread your rubber band through the inner slits, then through the outer.



Adjust and wear!



AHHHH!

I decorated mine with markers!



And I thought the NIGHTMARES were bad!

Grrrr.



The End!

CUT TO THE POINT

YOU NEED A HACKSAW TO CUT THE PVC FOR YOUR MARSHMALLOW SHOOTER, AND IN FACT YOU WILL NEED SAWING SKILLS THROUGHOUT YOUR LIFE.

DOVETAIL SAWS



Clean, sturdy cuts, great for frames, cabinets and toys.

BACK SAWS



Thick-bladed with reinforced back for precision cuts.

BOW SAWS



Steel frame and blade for rough-cuts of wood.

CROSSCUT SAWS



For cutting against the grain. Can be used for many purposes from logging to detailed carpentry.

RIP SAWS



For cutting with the grain. The ripping action of the saw produces a coarse, ragged cut, which makes the saw unsatisfactory for finish work.

COMPASS SAWS



Small blade used for cutting curved or straight holes.

KEYHOLE SAWS



Intricate, close, inside work for specialty jobs.

COPING SAWS



Cuts irregular shapes and intricate patterns.

CROSS CUT TEETH

Crosscut teeth are small teeth used to sever wood when cutting across the grain.

RIP TEETH

Rip teeth are medium-sized teeth designed to scoop out wood fibers when cutting with the grain.

CUTTING

This is the correct cutting position.

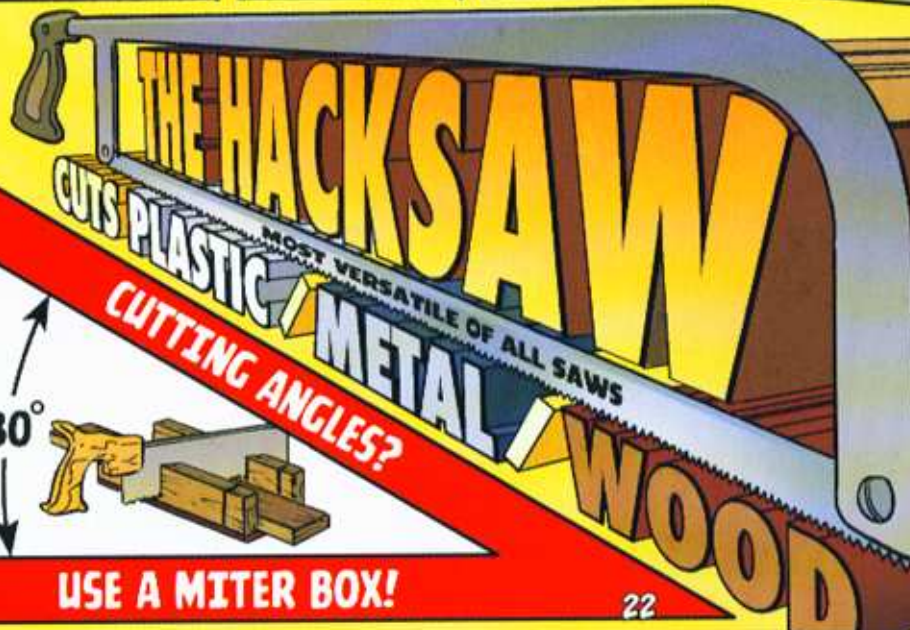
Your vision should always be true to the cutting plane, and always keep a straight line of action!

If possible use a clamp or vise to hold your piece and stop vibration.



1" 4 T.P.I.

T.P.I. stands for teeth per inch! Rule of thumb: the more T.P.I. the harder the material the saw can cut!



UPKEEP

A light coating of oil will make blades last longer. Be careful not to bend your saws. Hanging them up is a good method for storage.



THE INFAMOUS MARSHMALLOW SHOOTER!

I'm gonna
NAIL that BOOB
TUBE HEAD!

You can't
TOUCH
this!

IF YOU'RE A KID BROTHER OR SISTER,
HERE'S A YARN YOU KNOW ALL TOO WELL...

BECAUSE THIS ONE'S AN OL' FASHIONED SHOWDOWN!





L
ATER...

I had no idea
Celine was this
clever.



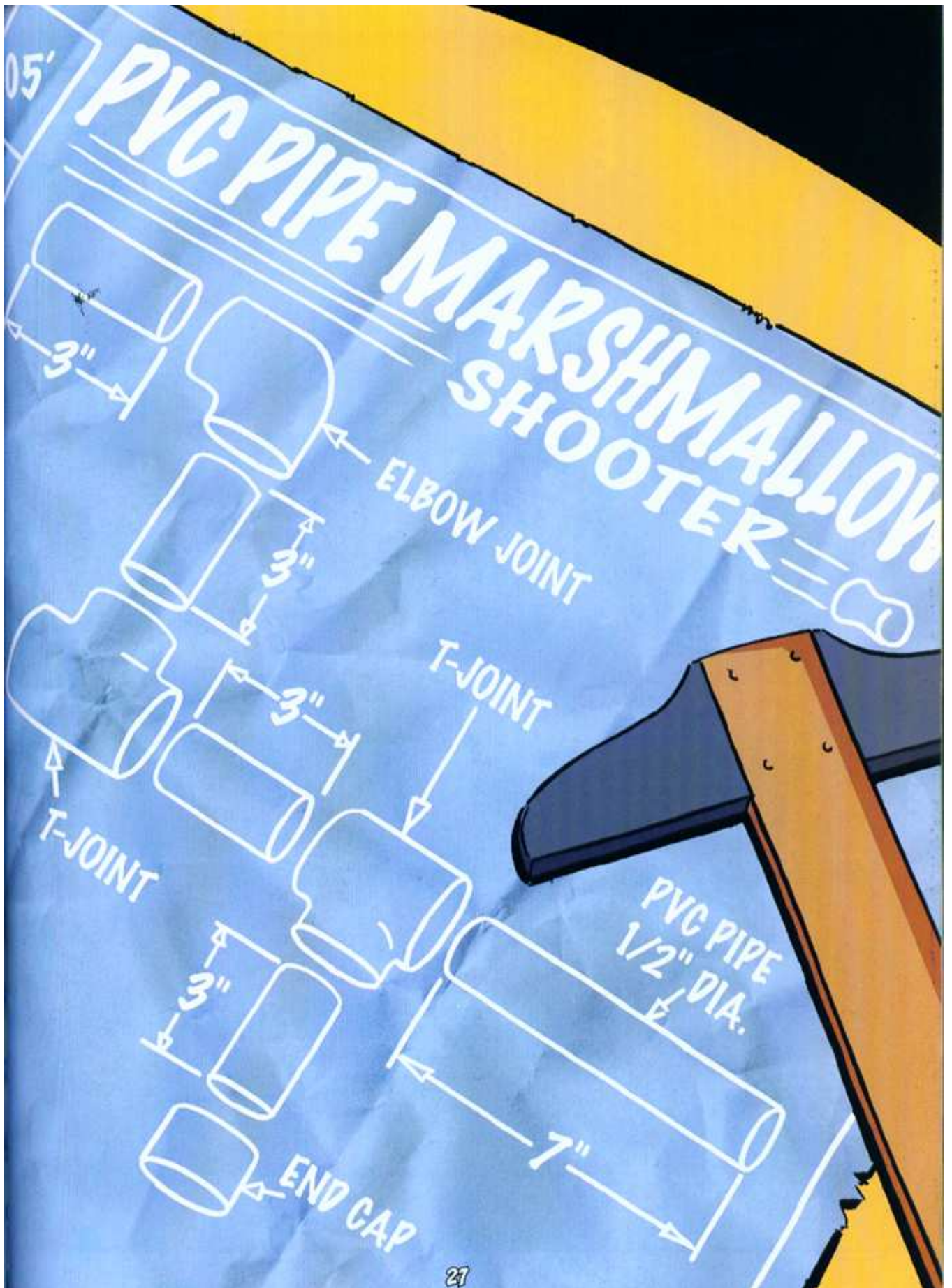
ELBOW JOINT

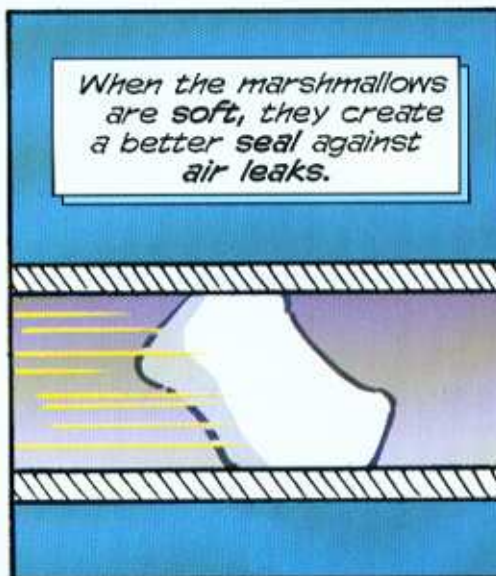
END CAP

3"
PVC PIPE
1/2" DIA.

MATERIALS

- 25 INCHES OF 1/2" INTERNAL DIAMETER PVC PIPE
- 2 ELBOW JOINTS
- 2 END CAPS
- 2 T-JOINTS

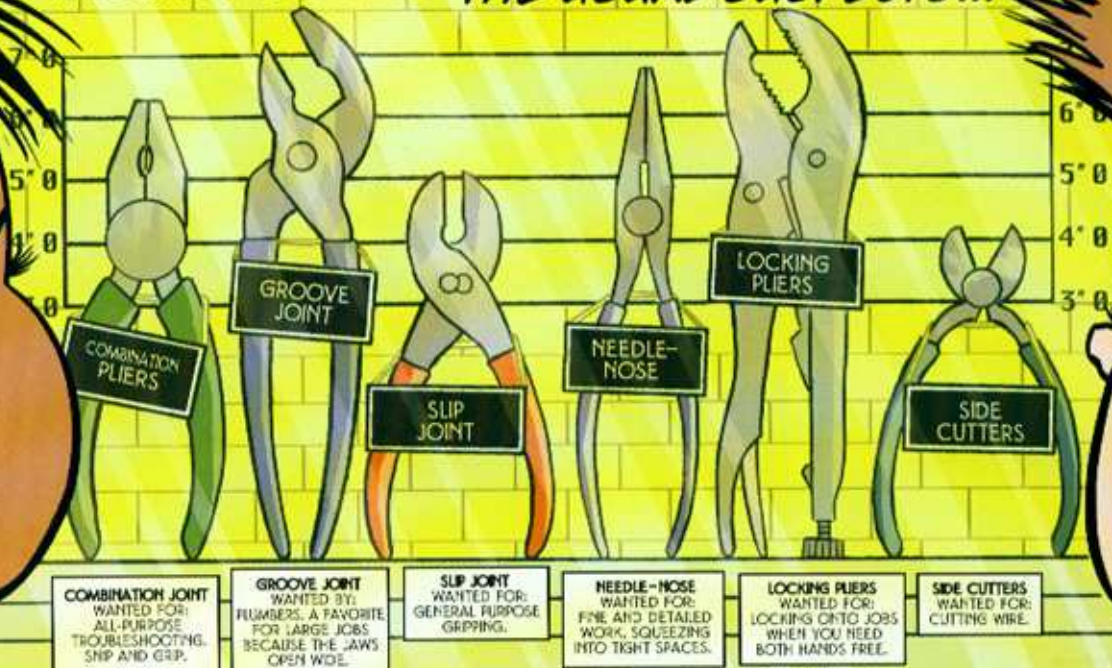






GET A GRIP

GRIP, SNIP, BEND, CUT, TWIST, CLAMP AND VISE. PLIERS ARE VERSATILE... GET TO KNOW THE USUAL SUSPECTS...



YO, FOOL! USE THE RIGHT TOOL!

MANY PLIERS HAVE SHEARS FOR CUTTING WIRE....



...PLACE THE EDGE OF THE JAWS OF THE PLIERS WHERE YOU WANT THE BEND AND USE YOUR OTHER HAND TO MAKE THE ANGLE. NEEDLE-NOSE PLIERS CAN BE USED TO MAKE TIGHT CORNERS.

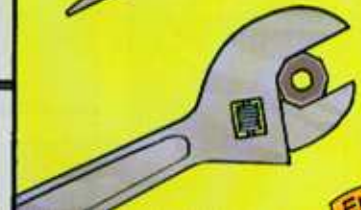


TEMPTING AS IT MAY BE... PLIERS SHOULD NOT BE USED TO TIGHTEN OR LOOSEN NUTS UNLESS IT IS AN ABSOLUTE EMERGENCY. BOTH NUTS AND THE PLIERS WILL BE DAMAGED!

WRONG!



RIGHT!



END!

The Happy Hippo

THE LION MAY BE KING OF THE JUNGLE, BUT SURELY THE HIPPO IS LORD OF THE LOWER LEVELS.

ITS NATURAL ENVIRONMENT IS A LUXURIOUS, AROMATIC SWAMP.

AMIDST TREES, FOLIAGE, FELLOW ANIMALS AND DENIZENS OF THE DEEP, THE HIPPO LURKS, STALKING GRASS IN PRODIGIOUS QUANTITIES.

They're beautiful.

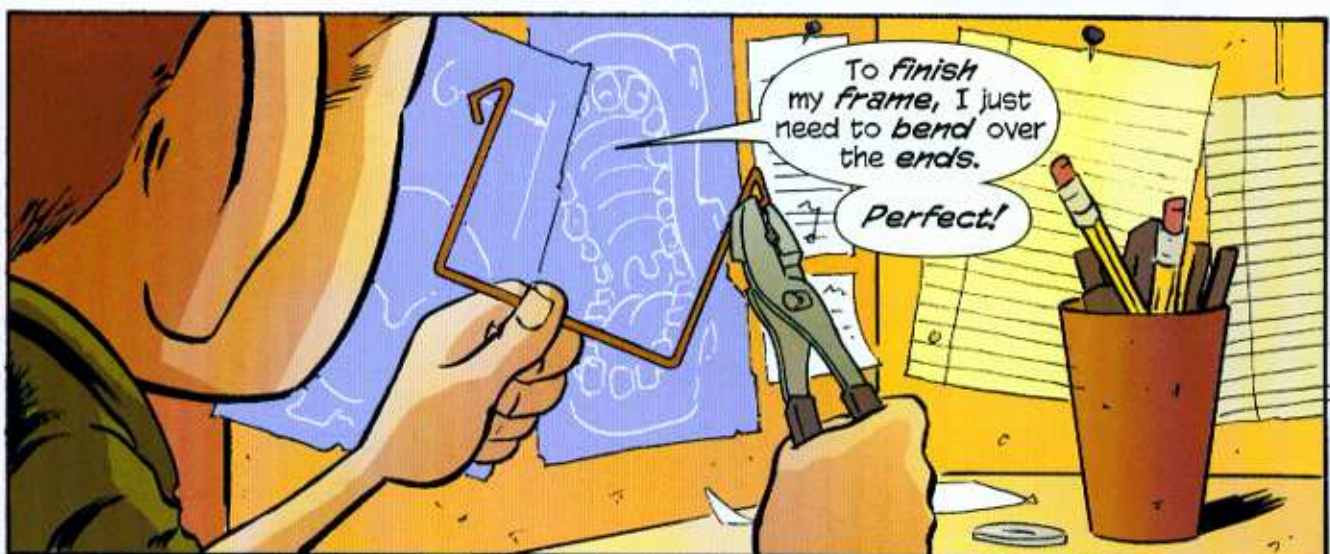
NDEED, THE HIPPO IS NEVER HAPPIER THAN WHEN IT SHARES ITS INNER ESSENCE WITH THE WORLD.

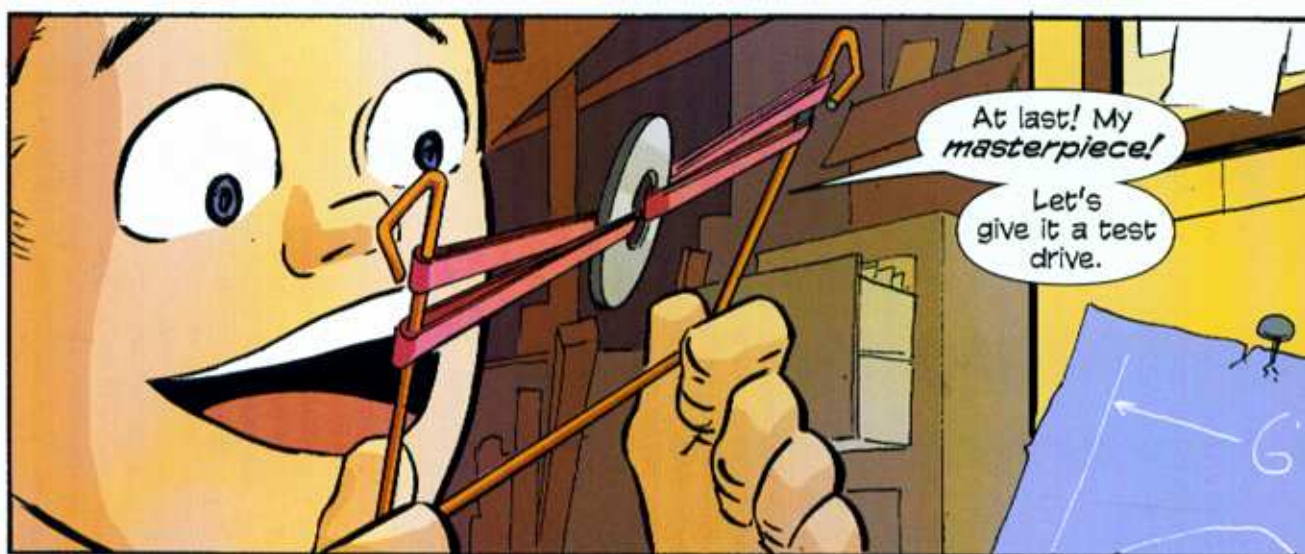
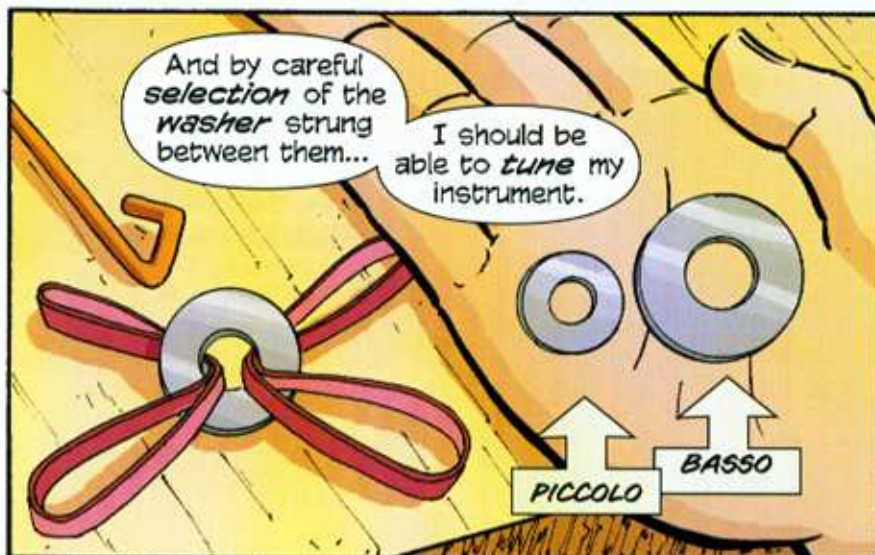
I will capture the inner essence of the hippo if it's the last thing I do!

OCCASIONALLY, A BIT OF EXCITEMENT BUBBLES UP.




















I'm going to need a spacecraft that can support human life for long periods of time without resupply ships...

And scientists haven't yet figured out how to create such a complex ecosystem. It's hard, like trying to make a miniature world...

And we humans haven't exactly figured out how not to pollute Earth, either...

So I'm practicing here in my...

TERRARIUM!



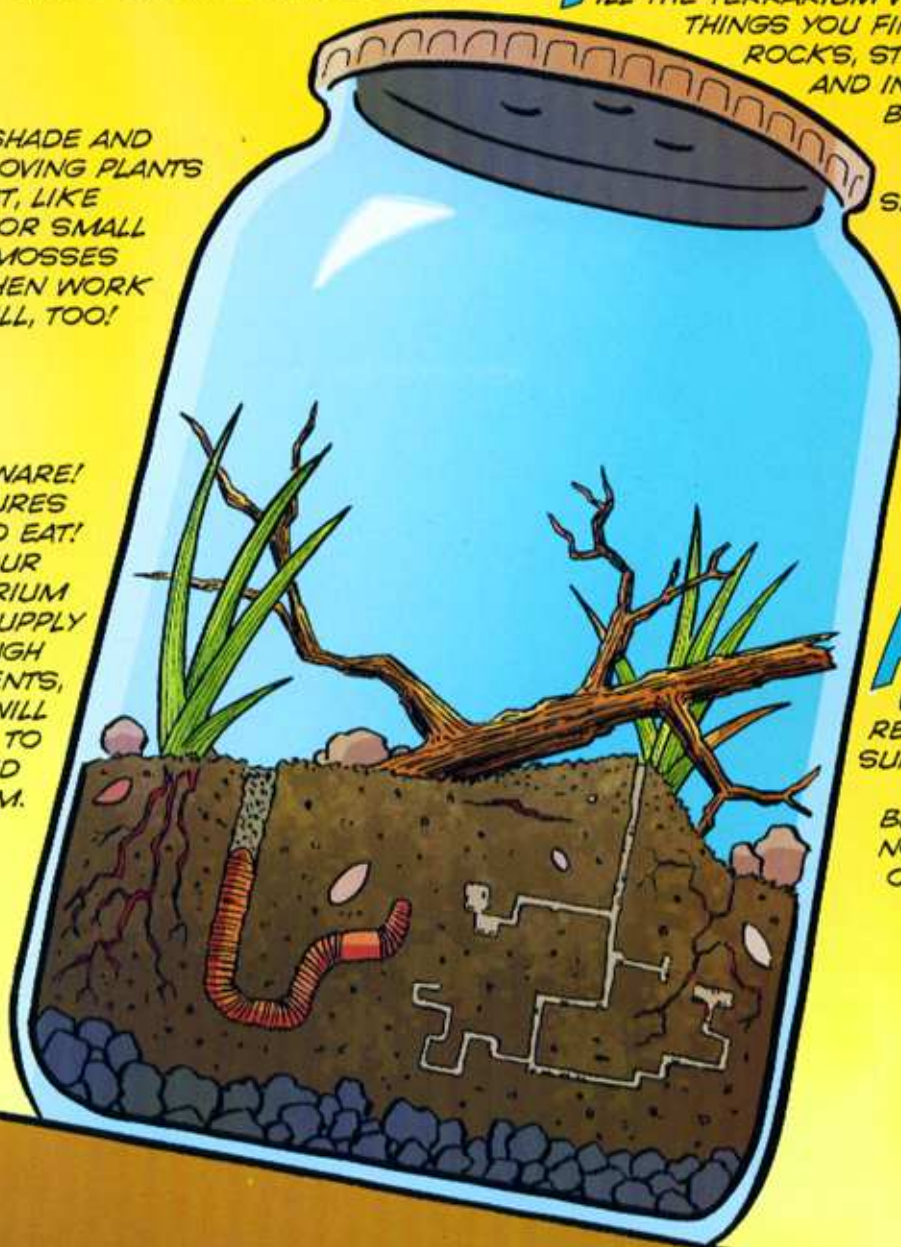
A NICE BIG PICKLE JAR WITH A LID WILL WORK NICELY. YOU COULD USE A FISH TANK, OR EVEN A LARGE SODA BOTTLE WITH THE TOP CUT OFF.

P LACE A FEW INCHES OF DIRT IN THE JAR, WITH PEBBLES ON THE BOTTOM TO GIVE IT BETTER DRAINAGE.

F ILL THE TERRARIUM WITH EVERYDAY THINGS YOU FIND IN NATURE: ROCKS, STICKS, WORMS AND INSECTS. IF YOU BUILD A REALLY LARGE ONE, YOU CAN TRY SMALL LIZARDS.

S MALL SHADE AND WATER-LOVING PLANTS ARE BEST, LIKE CLOVER OR SMALL FERNS. MOSSES AND LICHEN WORK VERY WELL, TOO!

B UT BEWARE! CREATURES NEED TO EAT! IF YOUR TERRARIUM CAN'T SUPPLY ENOUGH NUTRIENTS, YOU WILL HAVE TO FEED THEM.



P LACE THE JAR WHERE IT WILL RECEIVE PARTIAL SUNLIGHT. WATER ONCE IN THE BEGINNING, BUT NOT TOO MUCH, OR THE PLANTS WILL ROT. THE WATER VAPOR WILL STAY IN THE JAR AND BE CONTINUALLY RECYCLED.

Y OU CAN LEAVE THE TERRARIUM OPEN AT THE TOP BY PUTTING SMALL HOLES IN THE LID. THIS WAY IT CAN GET NUTRIENTS FROM THE OUTSIDE WORLD AND SURVIVE A LONG TIME. IF YOU SEAL IT COMPLETELY, YOU ARE RUNNING AN EXPERIMENT IN CLOSED ECOSYSTEMS. THE NUTRIENTS FROM THE SOIL FEED THE PLANTS, AND THE NUTRIENTS FROM THE PLANTS FEED THE INSECTS, AND THE CARBON DIOXIDE NEEDED BY ALL LIVING THINGS WILL HAVE TO BE BALANCED PERFECTLY BY THE WHOLE SYSTEM.

Wow!
It's so beautiful.
It really is like a
whole world in
there.

It makes
you think,
huh?

Like maybe
something's watching
over us. Just like we're
watching over the
terrarium.

Maybe,
Tuck...

Maybe.



*The
End!*

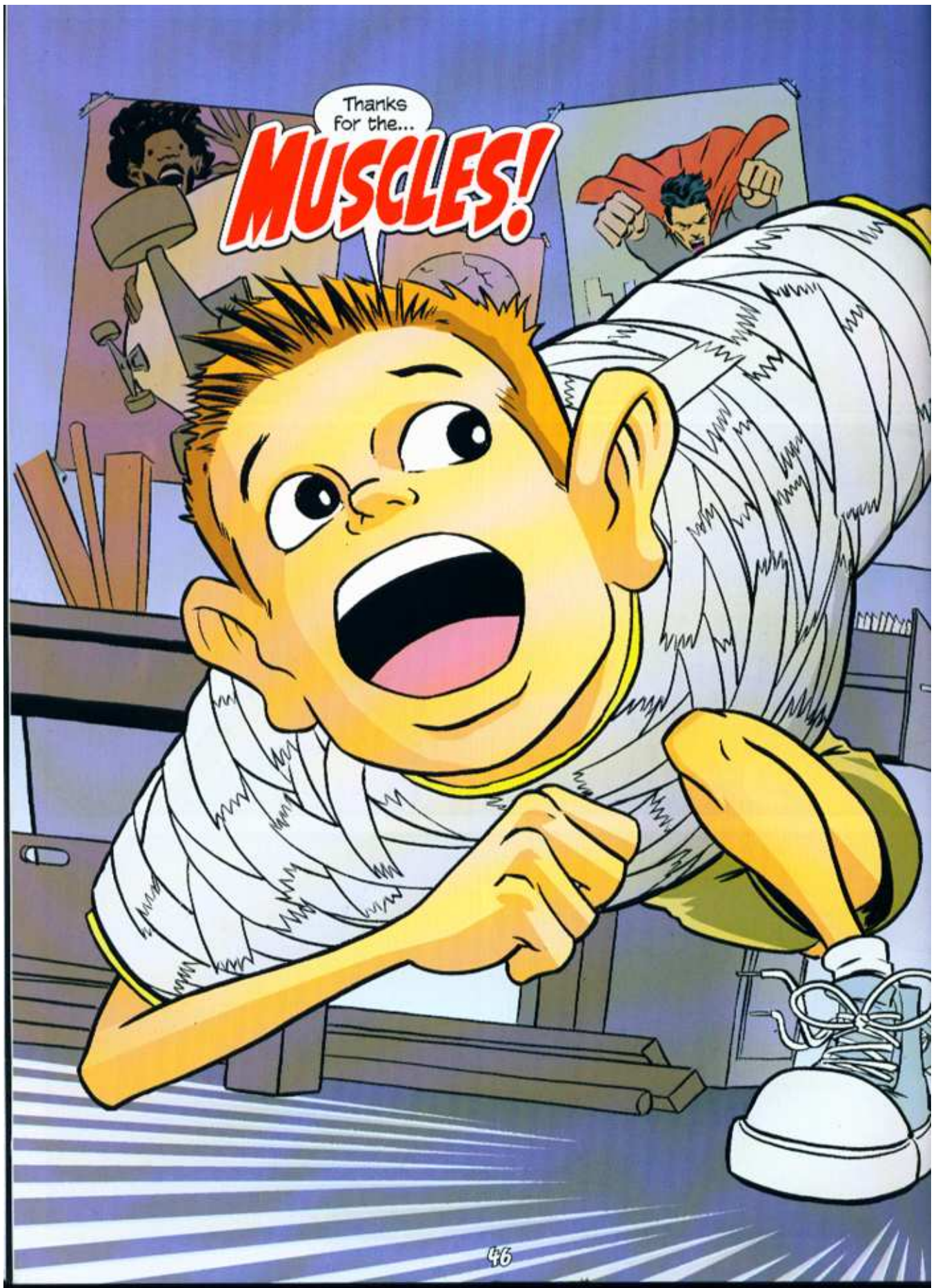
IT'S TIME TO... PUMP IT UP!

NO STEROIDS. NO PROTEIN POWDERS. NONE OF THOSE TEDIOUS HOURS AT THE GYM... FOLLOW OUR STEP-BY-STEP GUIDE TO INSTANT MUSCLES.











Thanks
for the help,
Tuck!

To make my
sewing dummy,
I just stuff the
inside of a form
made from a T-shirt
my size with
newspaper!

In order
to keep the
newspaper in,
I seal off all
holes at the arms,
neck, and
bottom.

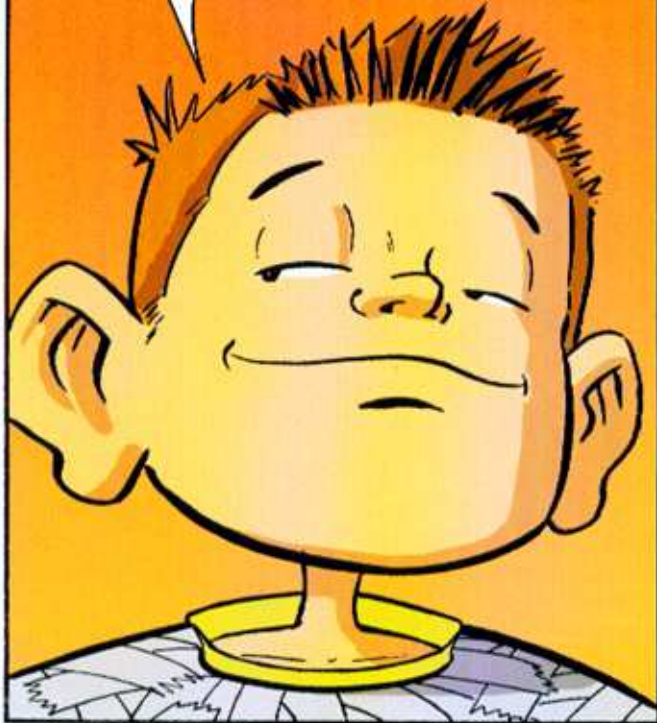
This is also a good
stage to shape it to your
physique! Just use scissors
to cut up the sides where
changes need to be made.

Now just
prop it up on
a base. I used
an old coat
rack!

And voilà!
Sewing dummies
are great for making
your own clothes.
Now I can finish my
spacesuit!

*TO BE READ IN YOUR BEST AUSTRIAN ACCENT!

Excuuuse me,
Ladeeez...*



Have you
seen...

my
beach
ball?



It's
about...

diss big!



And I
left it... over
dare.



EIT BY EIT



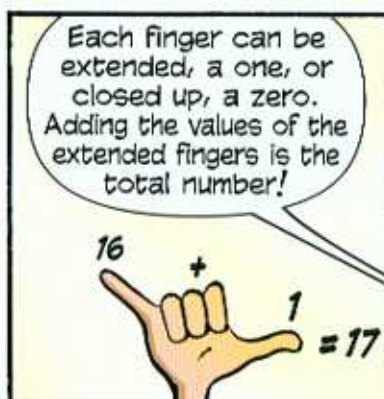
OUR ABSURD ADVENTURERS
GO TOTALLY DIGITAL



I'm so past that. I'm into counting in binary now. It's awesome. I have the capacity to count like a computer.



With a single hand I can count to 31; with two I can reach 1023! Enough even for my monster comic collection.



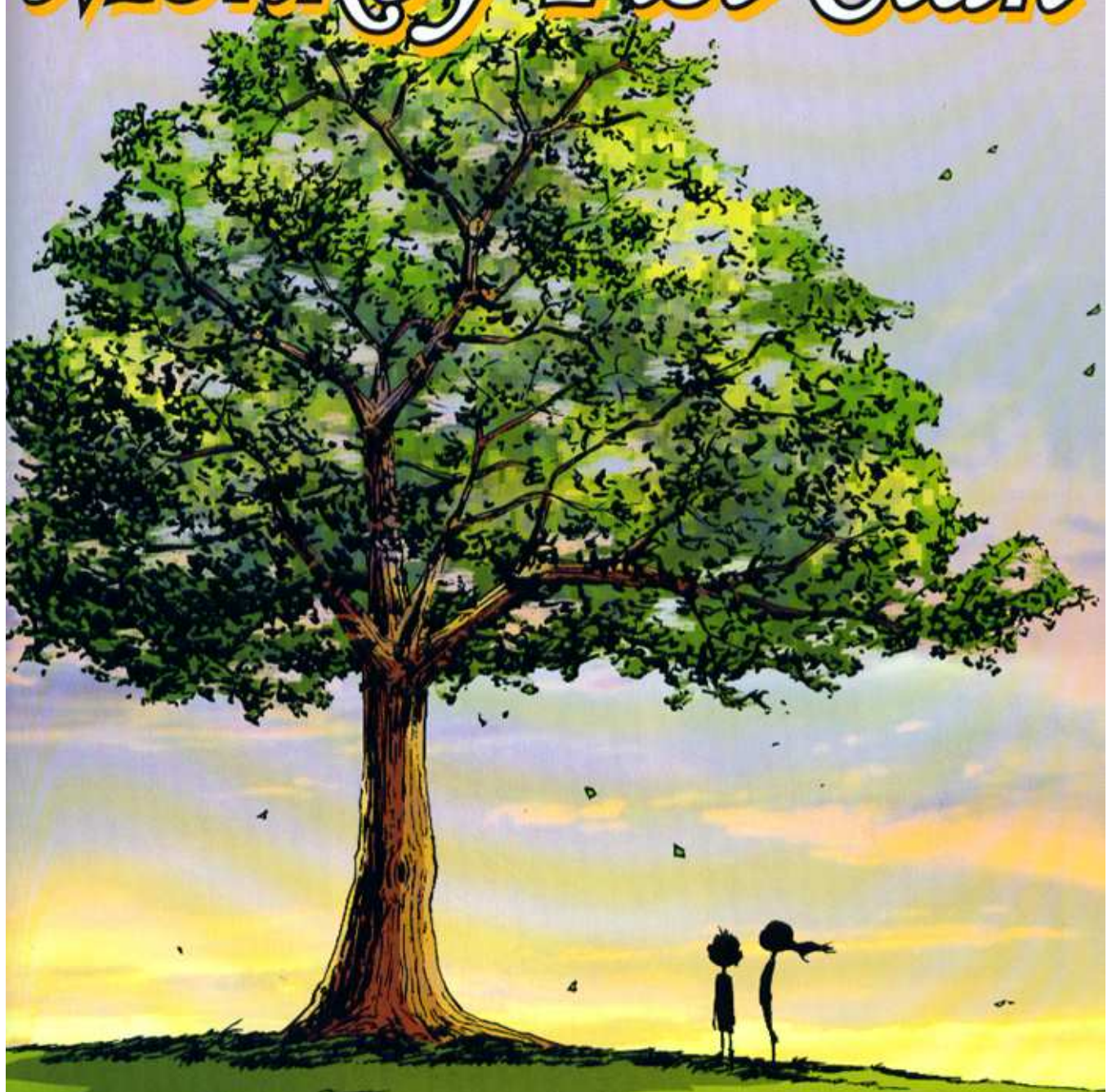
00000=0	00001=1	00010=2	00011=3	00100=4	00101=5	00110=6	00111=7
01000=8	01001=9	01010=10	01011=11	01100=12	01101=13	01110=14	01111=15
10000=16	10001=17	10010=18	10011=19	10100=20	10101=21	10110=22	10111=23
11000=24	11001=25	11010=26	11011=27	11100=28	11101=29	11110=30	11111=31



In electronics, the zeros and ones are represented by high and low voltages, or flashes of lights, not by my fingers... A zero or a one is called a bit.



Legend of the Monkey Fist Clan

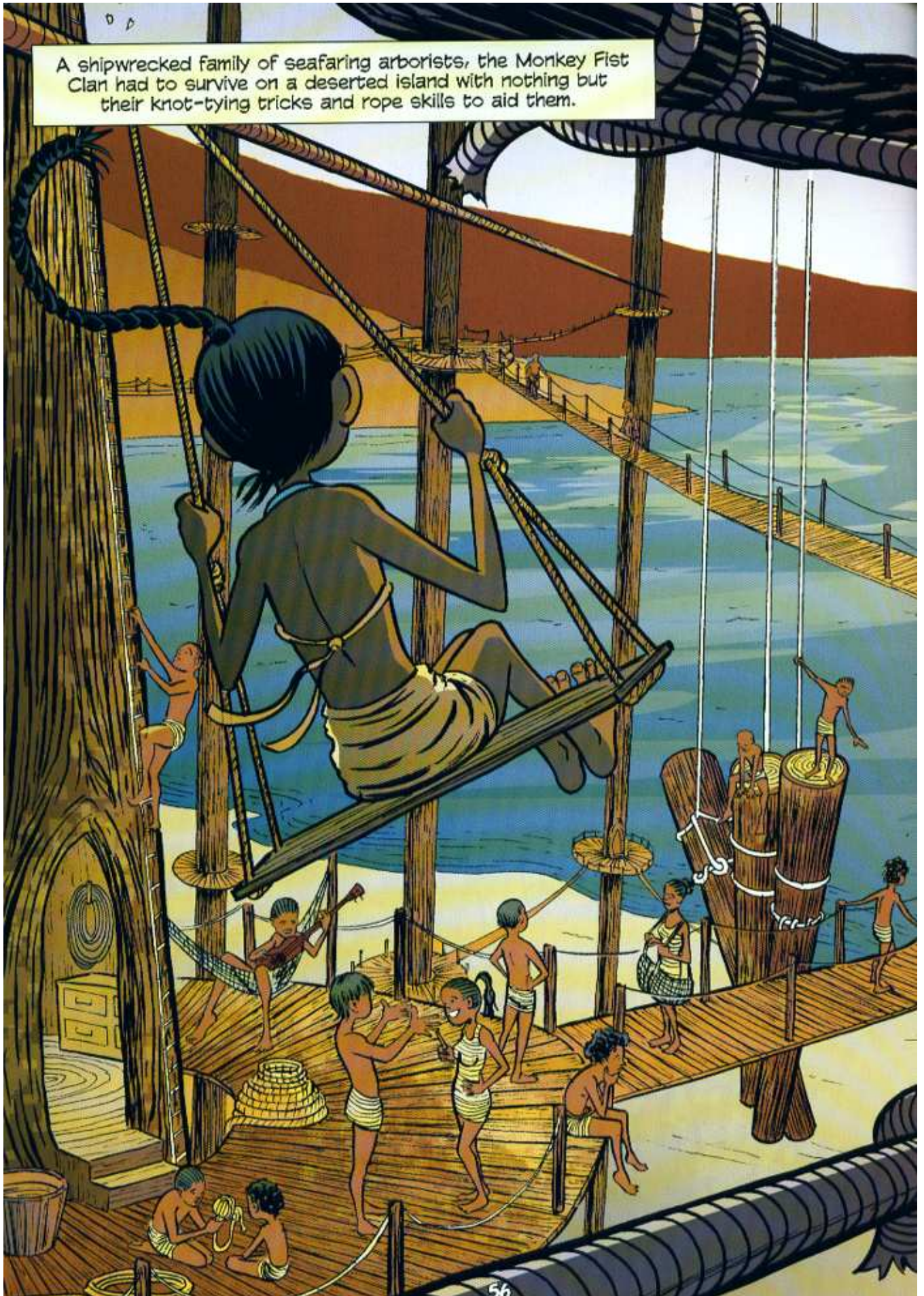


Always employ an experienced adult in the choice of a tree and installation of a tree swing.





A shipwrecked family of seafaring arborists, the Monkey Fist Clan had to survive on a deserted island with nothing but their knot-tying tricks and rope skills to aid them.





In order to survive they learned to use rope for everything; their braids, knots, splices and weaves transformed the desolate environment into a treehouse paradise.

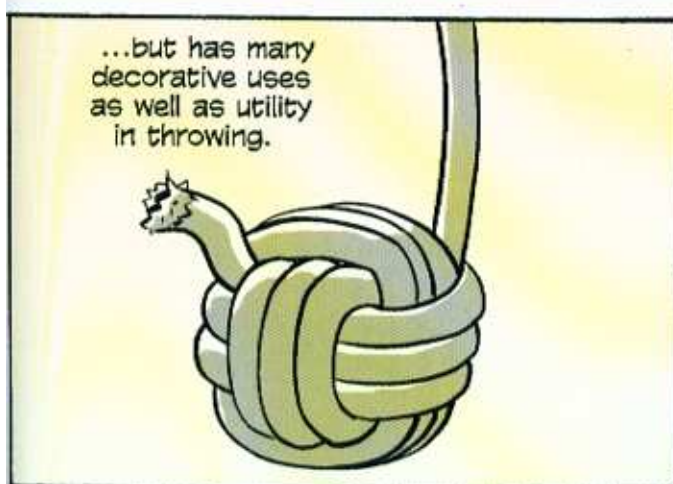
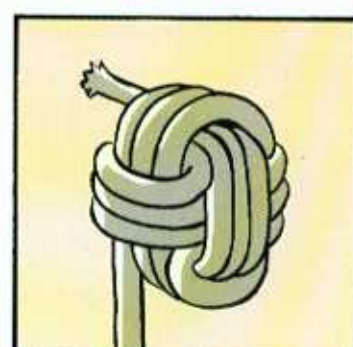
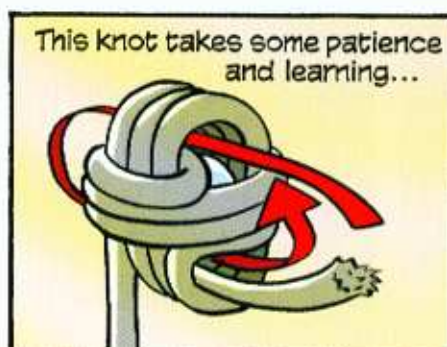
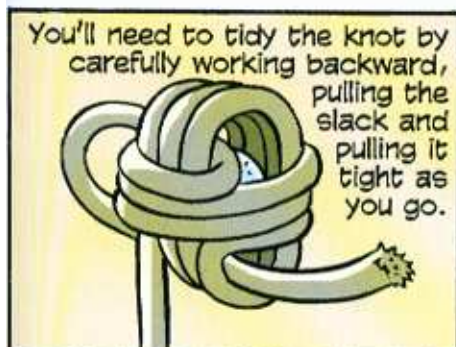
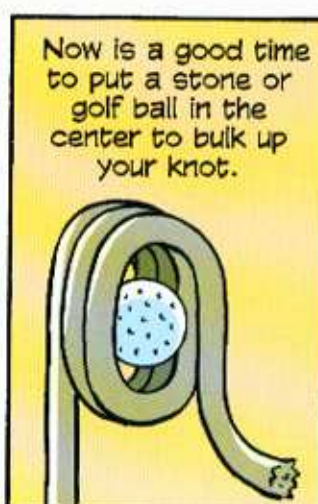
To throw their ropes, the clan developed a heaving knot, the Monkey's Fist. Mastery of this decorative, yet functional, knot was the first sign of adulthood.

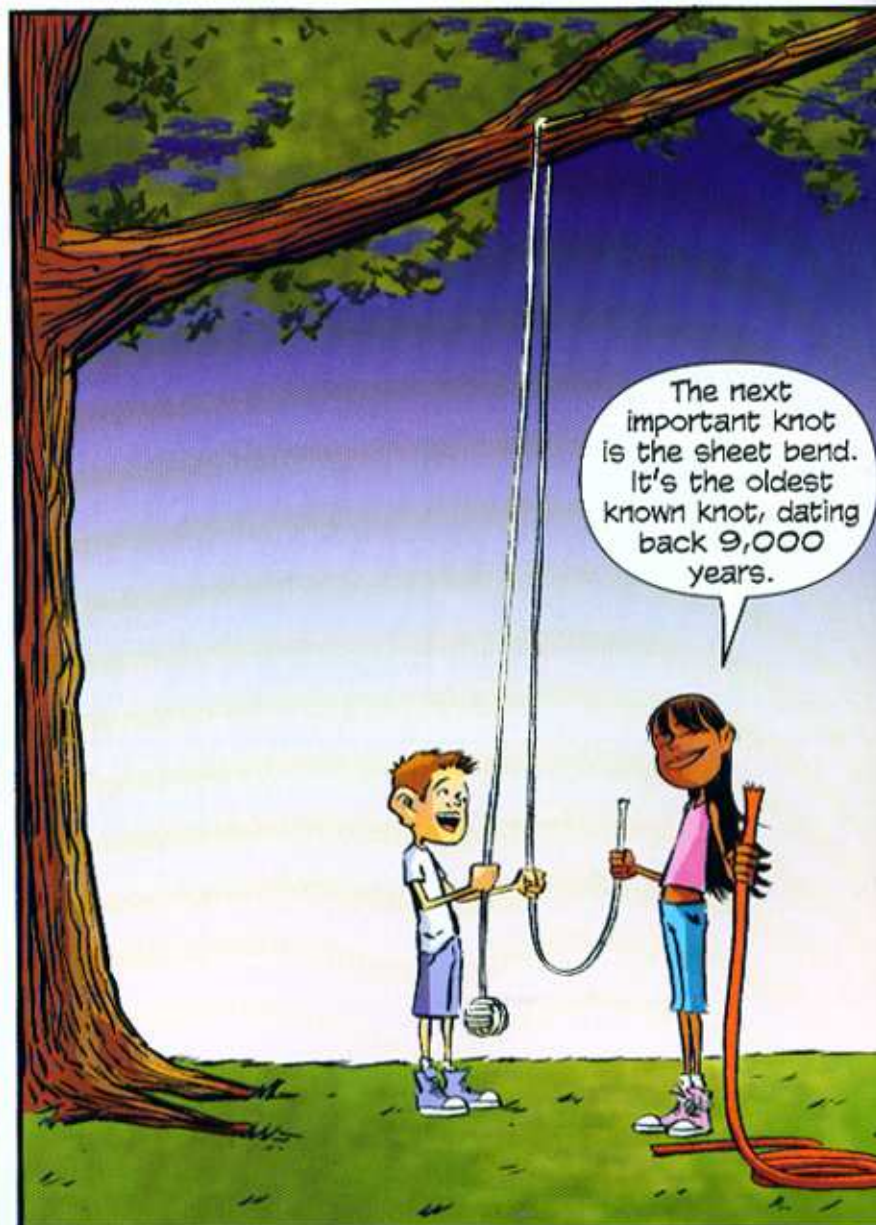


To scale
the highest trees
and taste the most
succulent fruit the clan
needed a number of
special knots...

Knots
they could
throw...

grip...
and
connect!





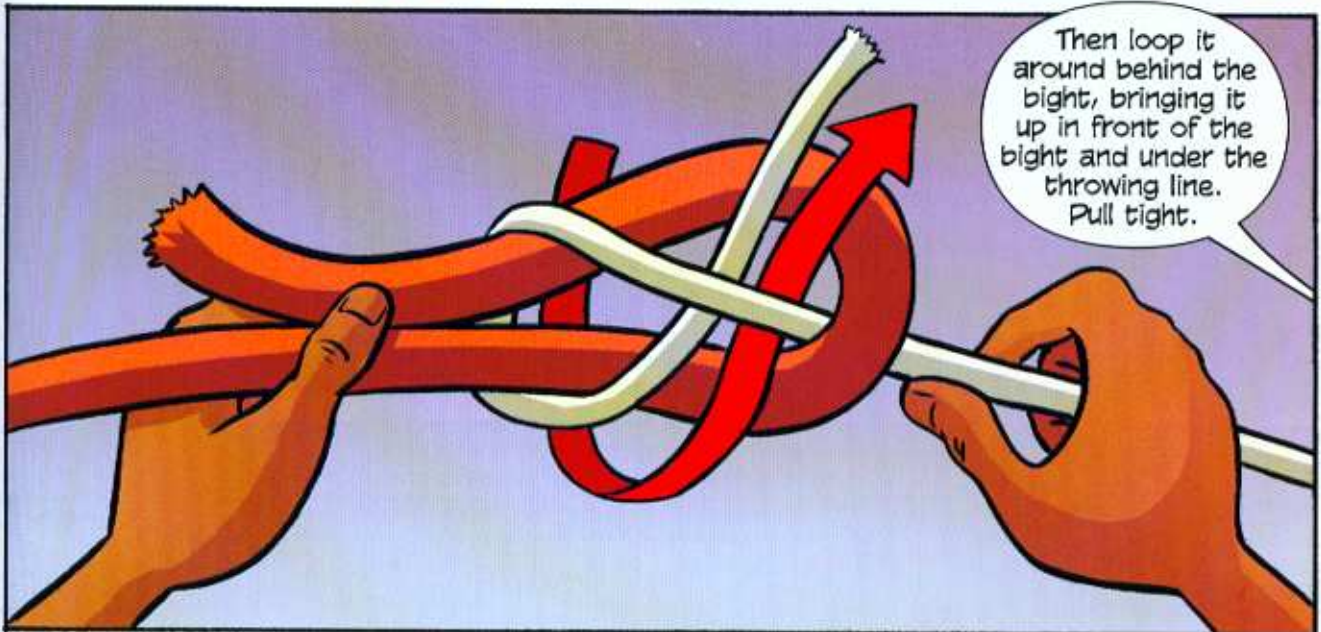
The sheet bend will join the lightweight heaving line,...

...which is the tail end of your monkey's fist...

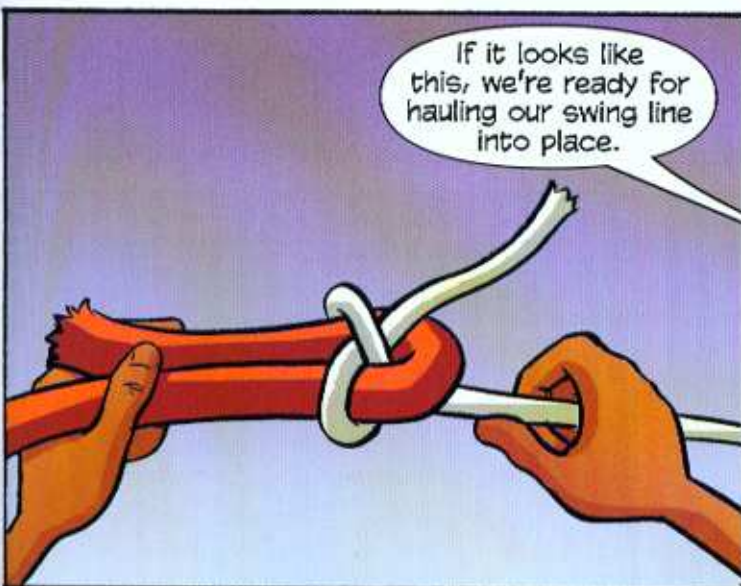
...to the sturdy piece of rope we'll use for swinging from the tree.

Use at least a 5/8" line for tying around the branch.

With the thick rope, you'll make a bight, which is a pinched loop. Thread the loose end of your throwing line through the bight.



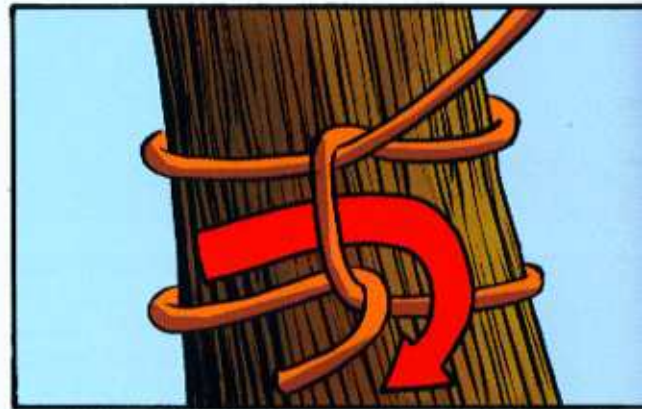
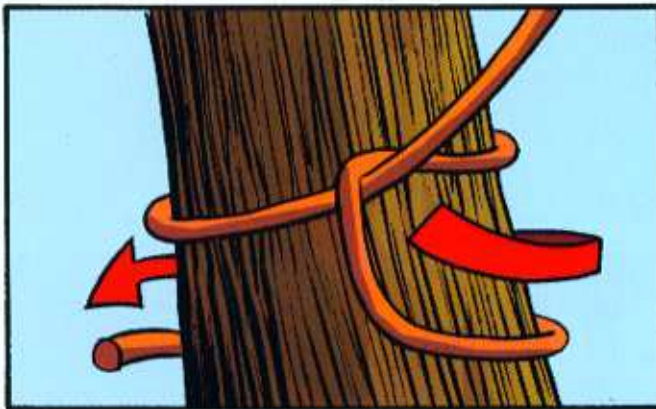
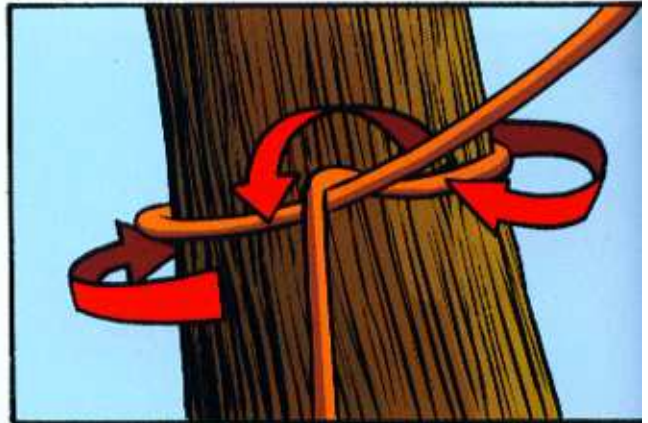
Then loop it around behind the bight, bringing it up in front of the bight and under the throwing line. Pull tight.



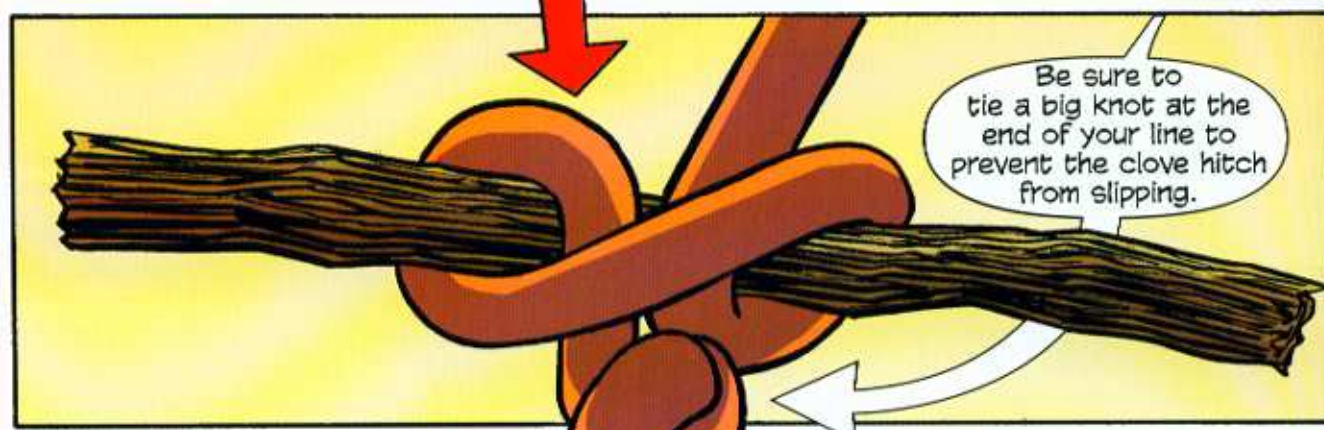
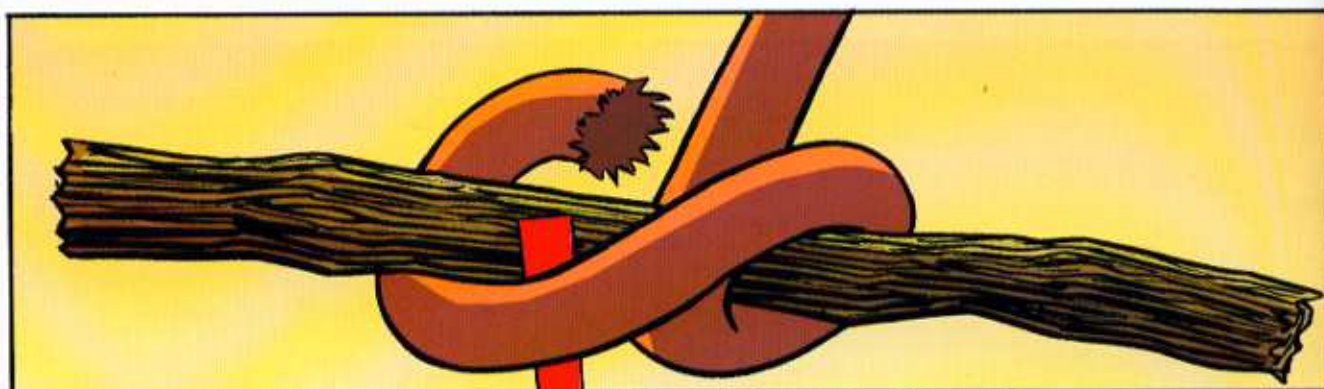
If it looks like this, we're ready for hauling our swing line into place.



Pull, Tuck! Pull!





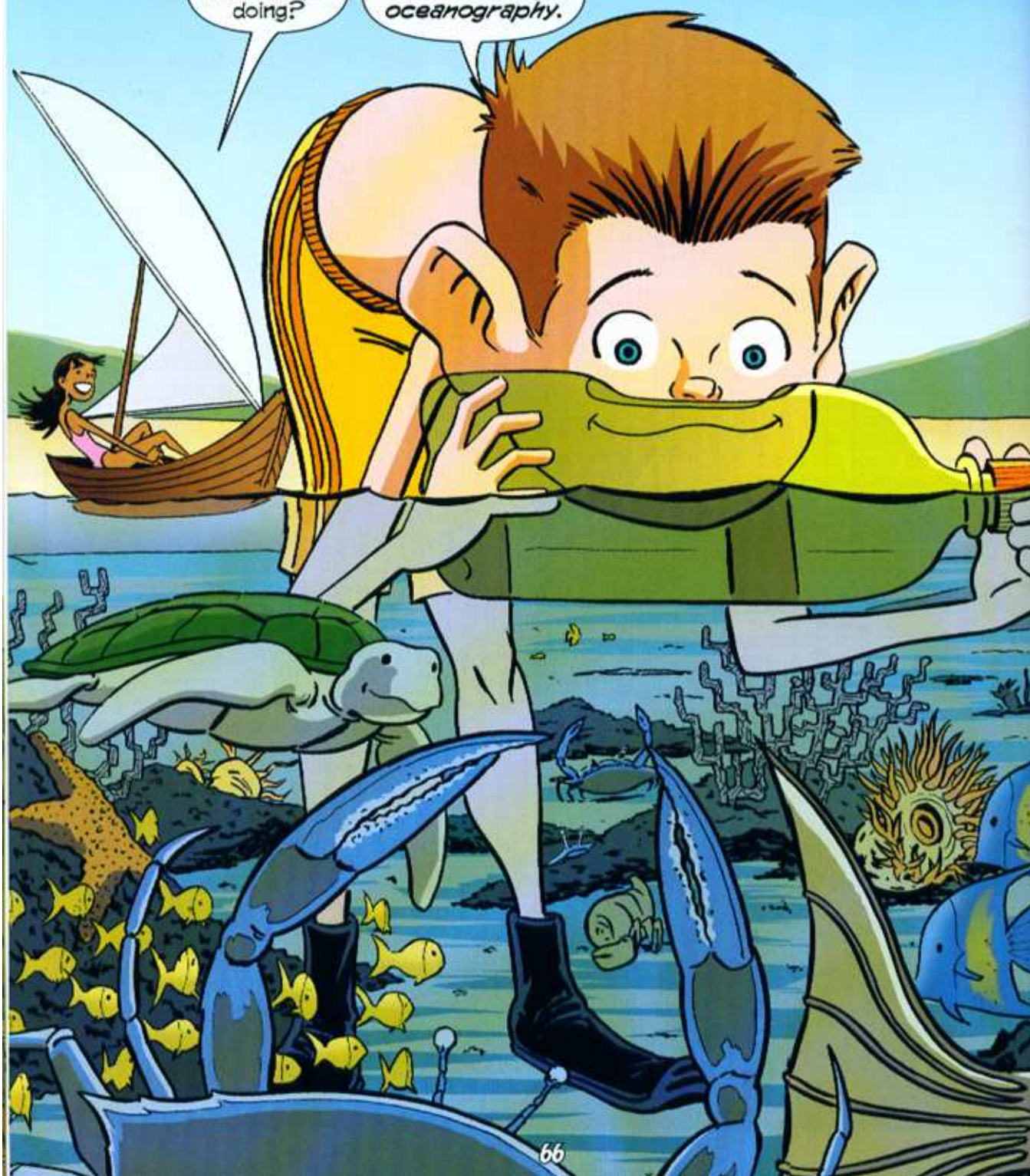




UNDERWATER SCOPE

Hey Tuck!
What are you
doing?

Nothing *really*.
Just some simple
oceanography.





The only things you need to make an underwater scope are a pair of scissors...

...and a 2-liter soda bottle.

An easy way to start your cut in the bottle is to squeeze it in the middle and make a small cut.

Cut the shape out below for your viewing pleasure.

Now just submerge the scope halfway into the water and start exploring.

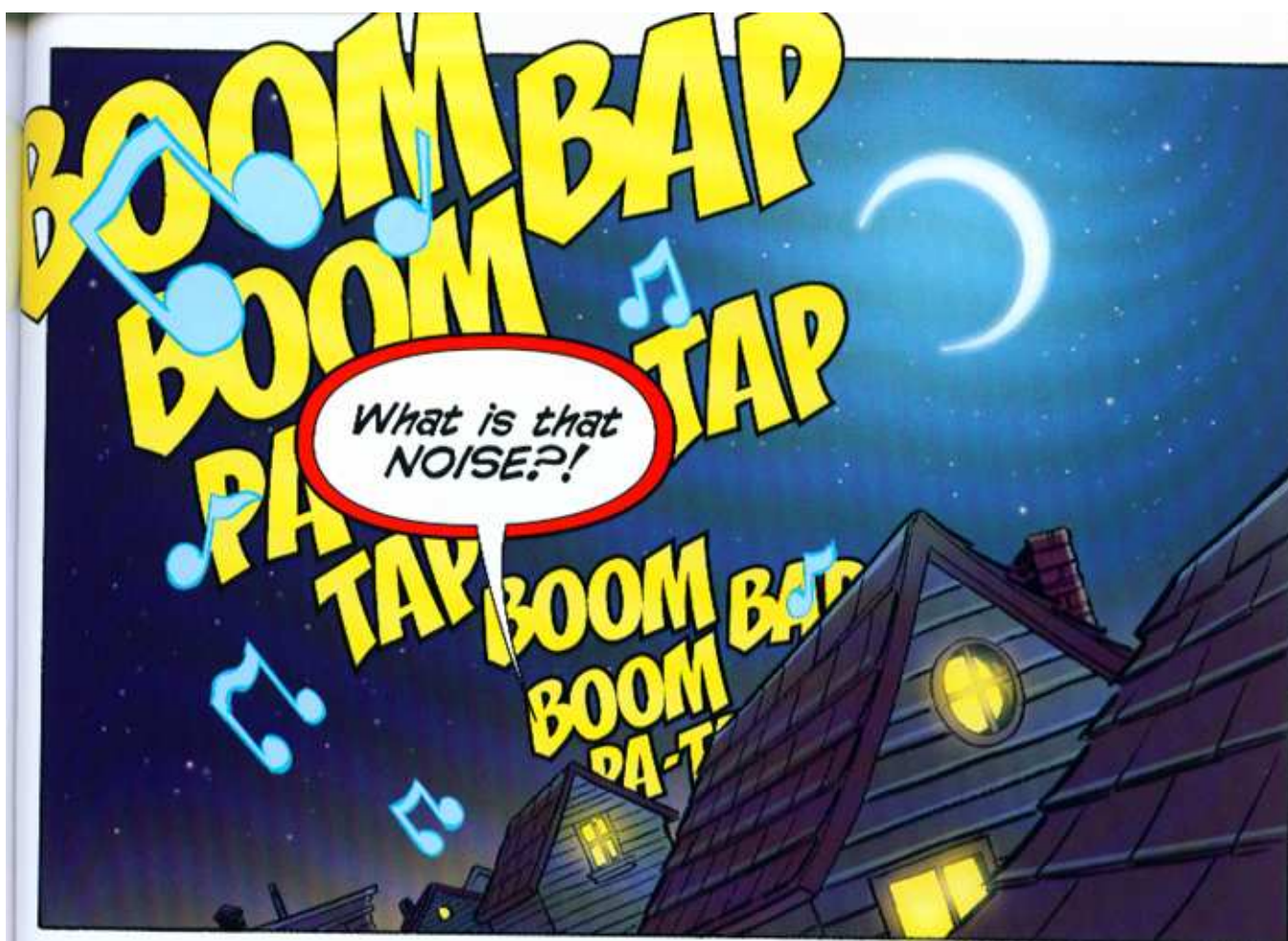
I wonder if this is how goggles were invented?

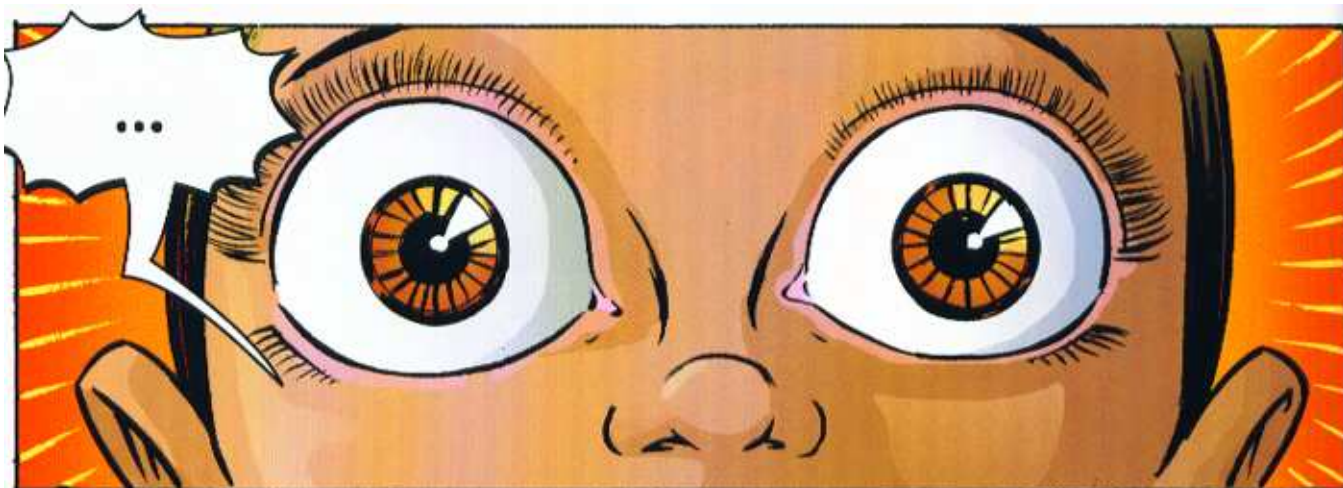
The End!

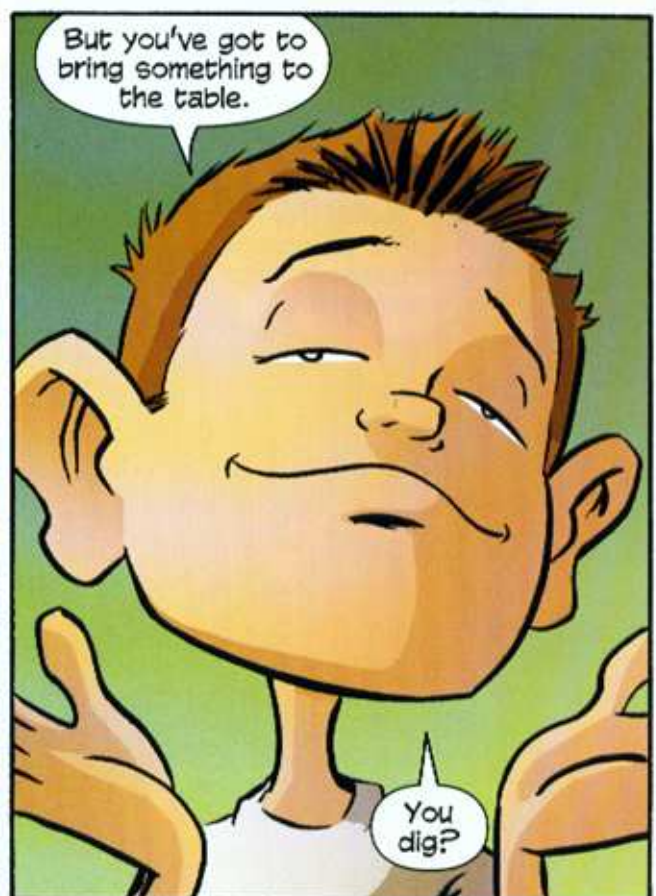
FOR THOSE ABOUT TO ROCK,

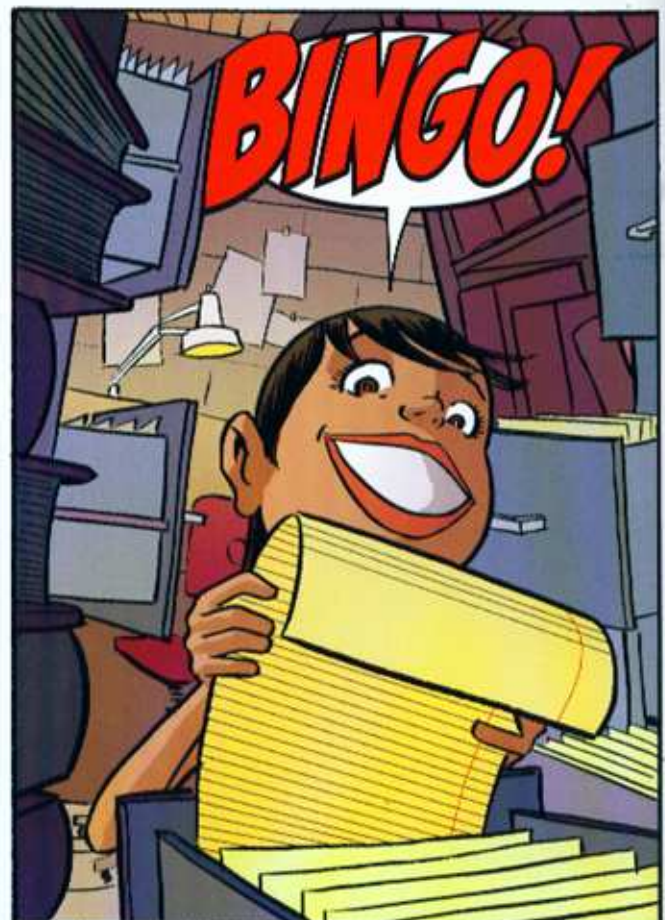


WE SALUTE YOU!









The
turkey-baster
flute!

FLUTE

MATERIALS

- BASTER
- RUBBER BANDS
- CUP OF WATER



TO MAKE A FLUTE, FILL THE TURKEY-BASTER UP HALF WAY.

HAVING A GOOD TECHNIQUE IS VITAL TO GETTING A GOOD SOUND ON YOUR FLUTE.

IT IS IMPORTANT TO HOLD THE BASTER TOP AT THE CORRECT ANGLE AGAINST THE LOWER LIP.

BY BLOWING A SMOOTH JET OF AIR ACROSS THE TOP, A TONE IS PRODUCED!

FLAUTISTS CALL THIS THE EMBOUCHURE, AND IT CAN TAKE YEARS TO PERFECT.

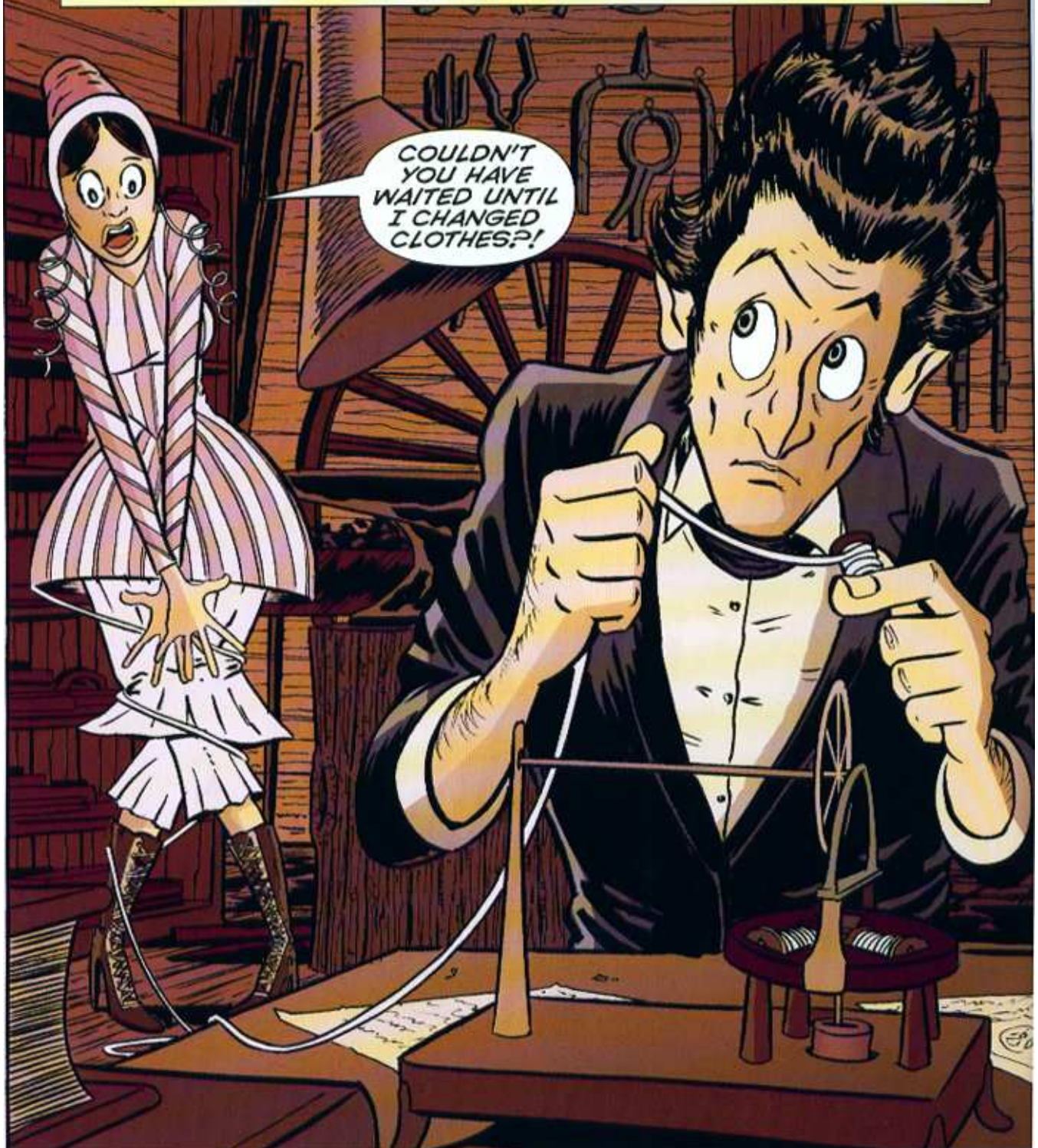
BY SQUEEZING THE BULB AND CHANGING THE WATER LEVEL, YOU CAN CHANGE THE NOTES.

TUNE YOUR FLUTE BY PLACING RUBBER BANDS AT WHOLE NOTE INTERVALS.



A NEW SPIN ON THINGS

In 1834, blacksmith and inventor Thomas Davenport built the first direct current electric motor. He went on to build the first model electric railroad. In his humble workshop in Vermont, Thomas used the threads of his wife Emily's silk wedding dress for the insulation around the wires of his motor. After years of struggle and persistence, Davenport's motor came to revolutionize science and industry.



Building your own super-simple electric motor is easy, given a little patience and some simple objects.

The key to making the electric motors that drive everything from forklifts to toothbrushes is the coil of insulated wire. As a current passes around the coil it turns the loop into an electromagnet. The permanent magnet and electromagnet then push and pull on each other to create motion.

The safety pins conduct electricity up from the battery into the coil.

The safety pins act as the simplest possible "commutator"; that's what makes everything work. As the axle rotates in the safety pin, it turns the current from the battery on and off each rotation, which turns the electromagnet on and off.

A rubber band will hold your safety pins to the battery, and the magnet will stick to the battery naturally.

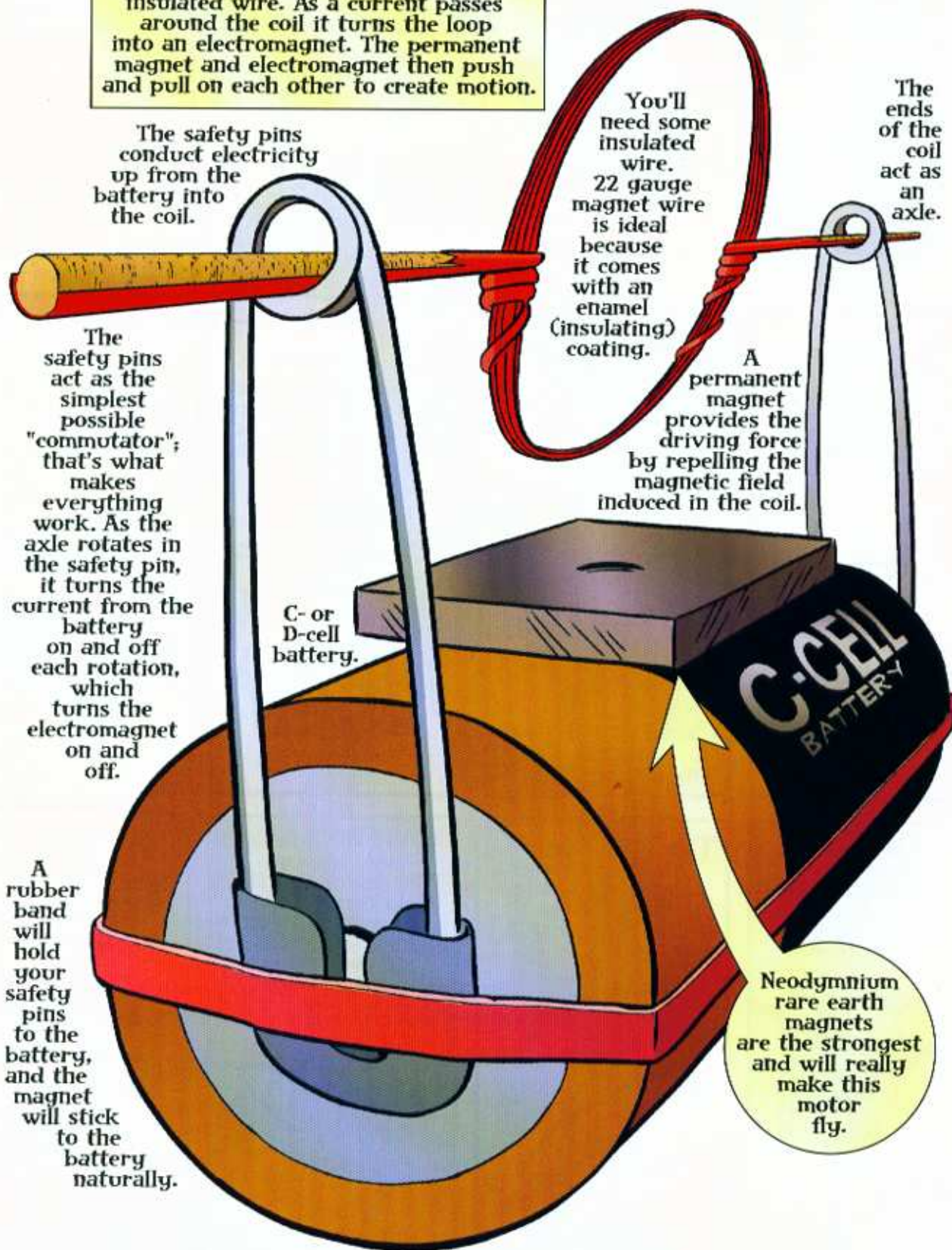
You'll need some insulated wire. 22 gauge magnet wire is ideal because it comes with an enamel (insulating) coating.

The ends of the coil act as an axle.

A permanent magnet provides the driving force by repelling the magnetic field induced in the coil.

C- or D-cell battery.

Neodymium rare earth magnets are the strongest and will really make this motor fly.



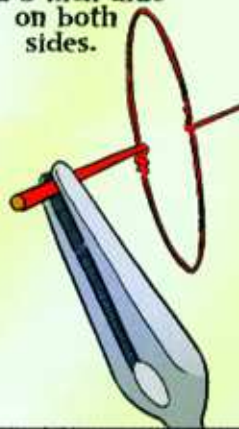
Start with your magnet wire.



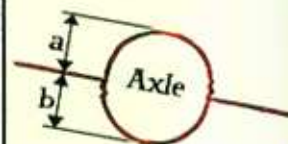
Wrap it 10-12 times around a C- or D-cell battery.



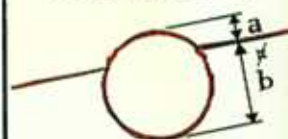
Wrap the loose ends 3-4 times around the coil you have created and cut a 2-3 inch axle on both sides.



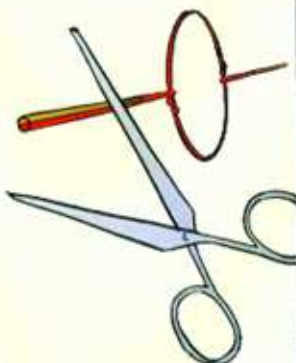
To make your motor really spin you will need to balance its coil. It needs to be symmetrical about the axle.



Make sure $a = b$



To get the electricity into your coil, you need to remove the insulation from the wire at both ends of the axle.

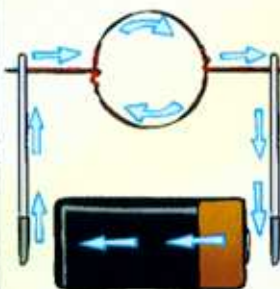


A knife or one blade of a pair of scissors will do this perfectly.



Carefully scratch the insulation off one side of the axle.

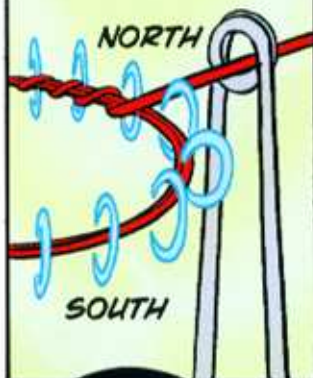
Threading the axle through the safety pins and connecting them to the battery allows the current to pass through.



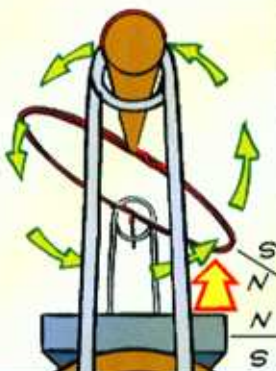
The current in the loop induces a magnetic field. The rubber band holds everything in place.



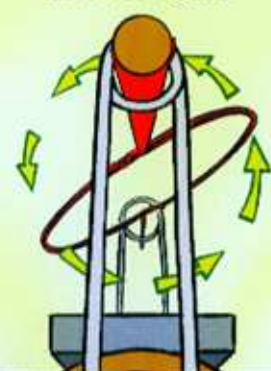
The induced magnetic field is north poled on one side of the coil and south poled on the other.



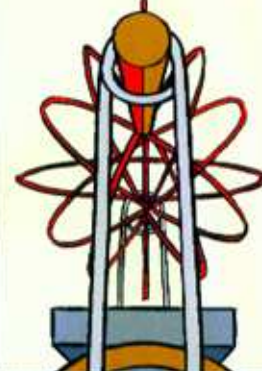
This field is repelled by the permanent magnet and kicks the coil over.



When the insulated side touches the safety pin, the field turns off and the coil can spin right around to do it all over again.



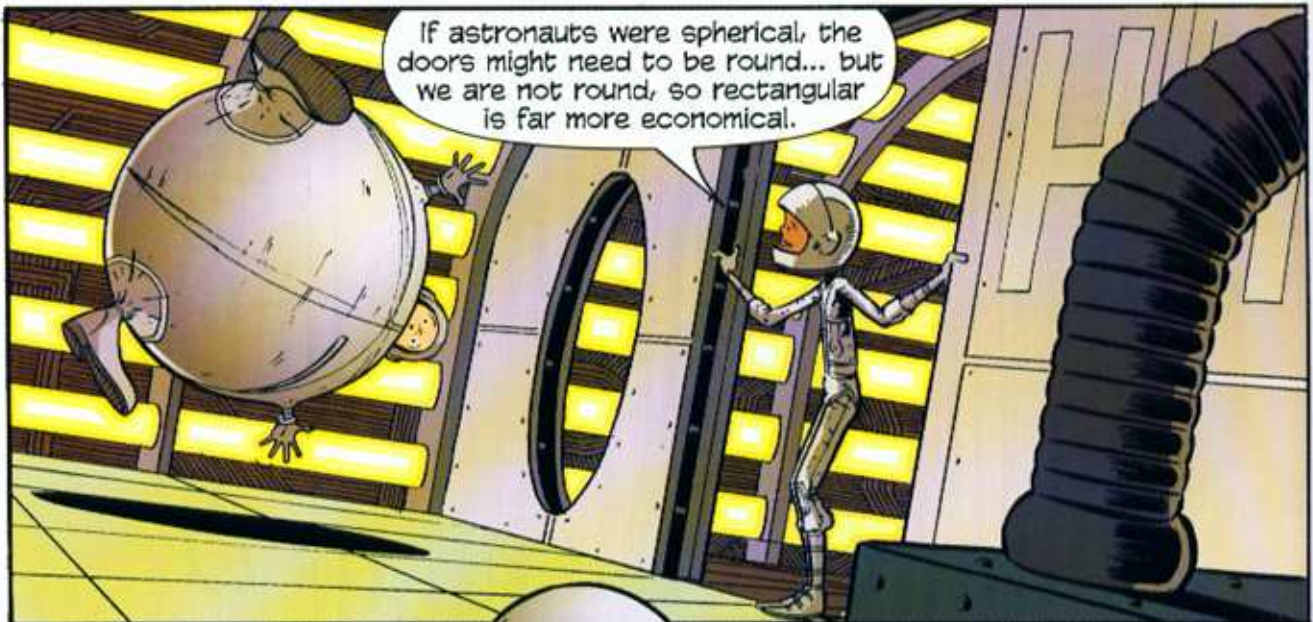
As it spins, the motor gets a little magnetic kick on every revolution, keeping it spinning.



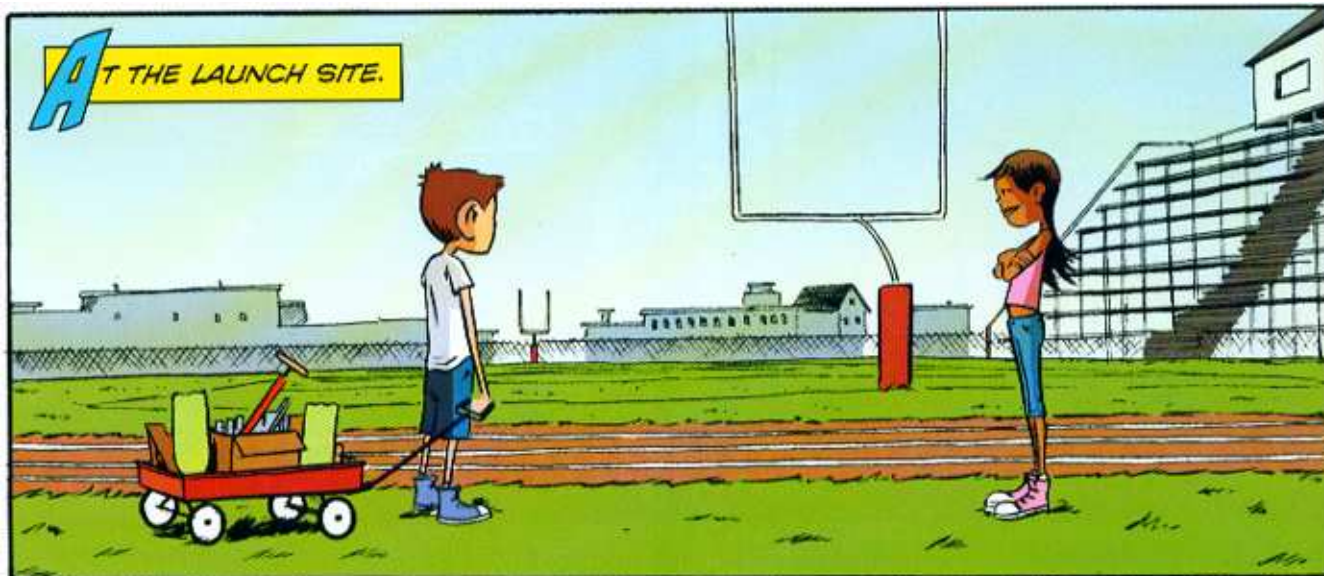
THE RIGHTEOUS STUFF



GO WHERE NO KID HAS GONE BEFORE



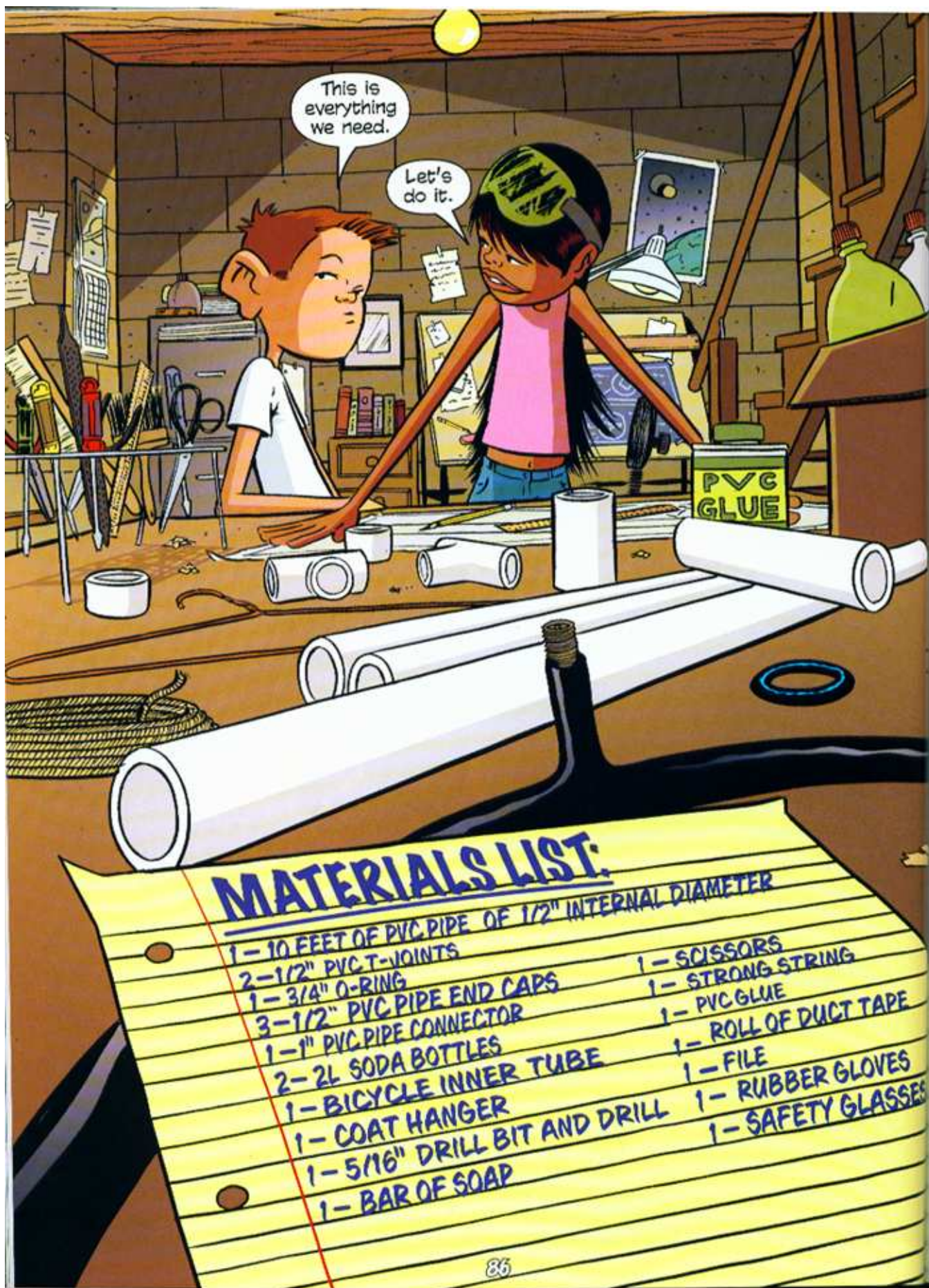










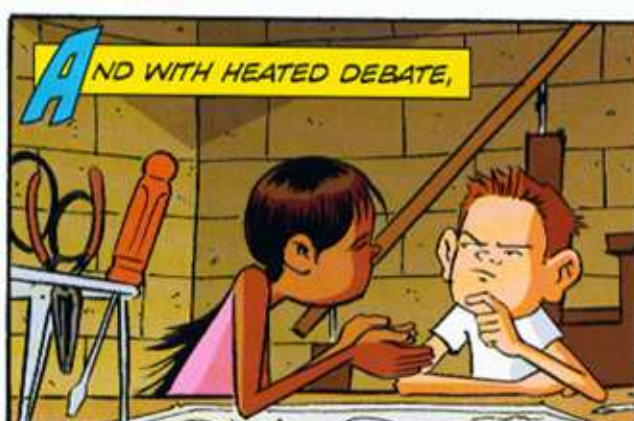


This is everything we need.

Let's do it.

MATERIALS LIST:

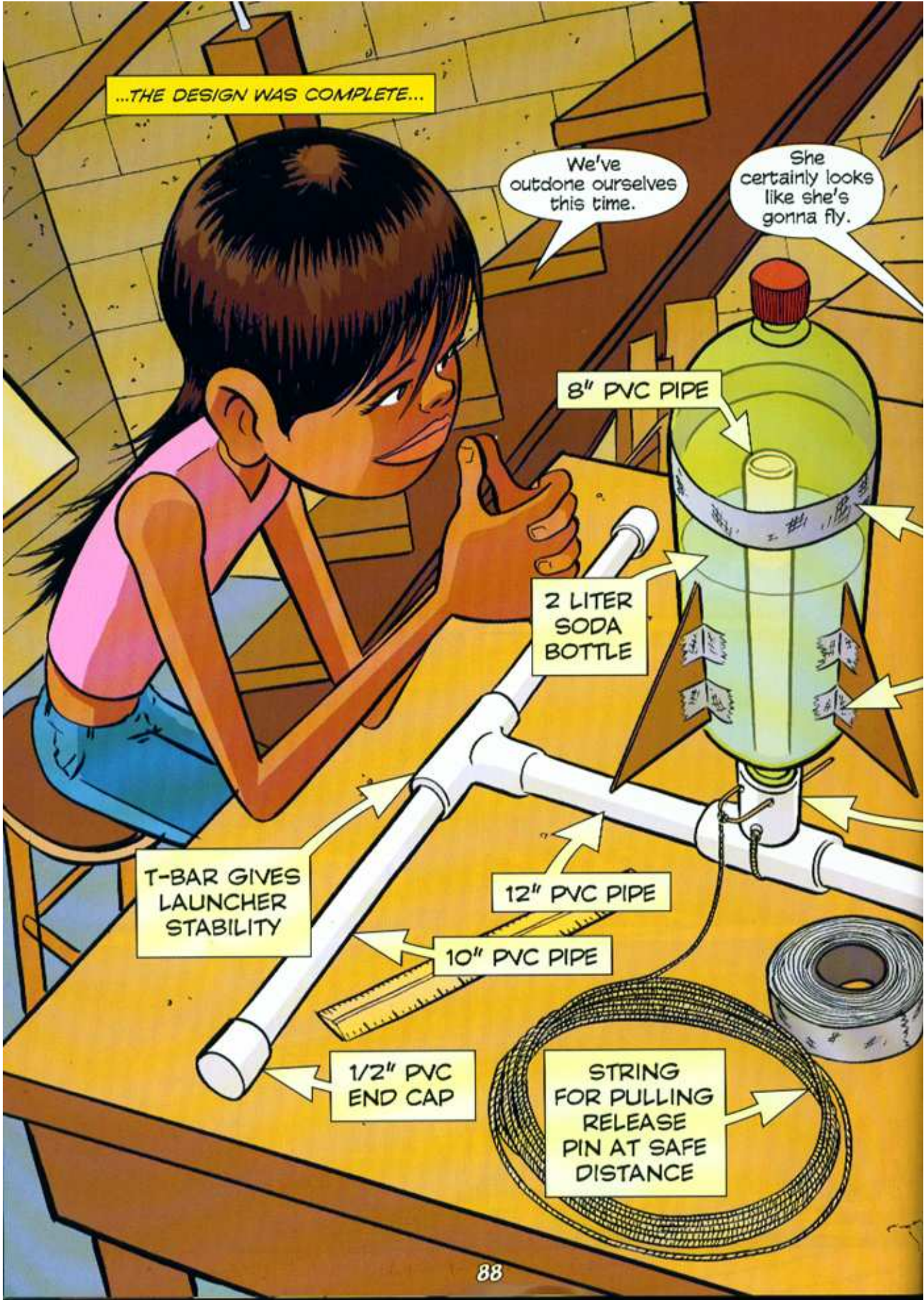
- 1 - 10 FEET OF PVC PIPE OF 1/2" INTERNAL DIAMETER
- 2 - 1/2" PVC T-JOINTS
- 1 - 3/4" O-RING
- 3 - 1/2" PVC PIPE END CAPS
- 1 - 1" PVC PIPE CONNECTOR
- 2 - 2L SODA BOTTLES
- 1 - BICYCLE INNER TUBE
- 1 - COAT HANGER
- 1 - 5/16" DRILL BIT AND DRILL
- 1 - BAR OF SOAP
- 1 - SCISSORS
- 1 - STRONG STRING
- 1 - PVC GLUE
- 1 - ROLL OF DUCT TAPE
- 1 - FILE
- 1 - RUBBER GLOVES
- 1 - SAFETY GLASSES



...THE DESIGN WAS COMPLETE...

We've outdone ourselves this time.

She certainly looks like she's gonna fly.



8" PVC PIPE

2 LITER SODA BOTTLE

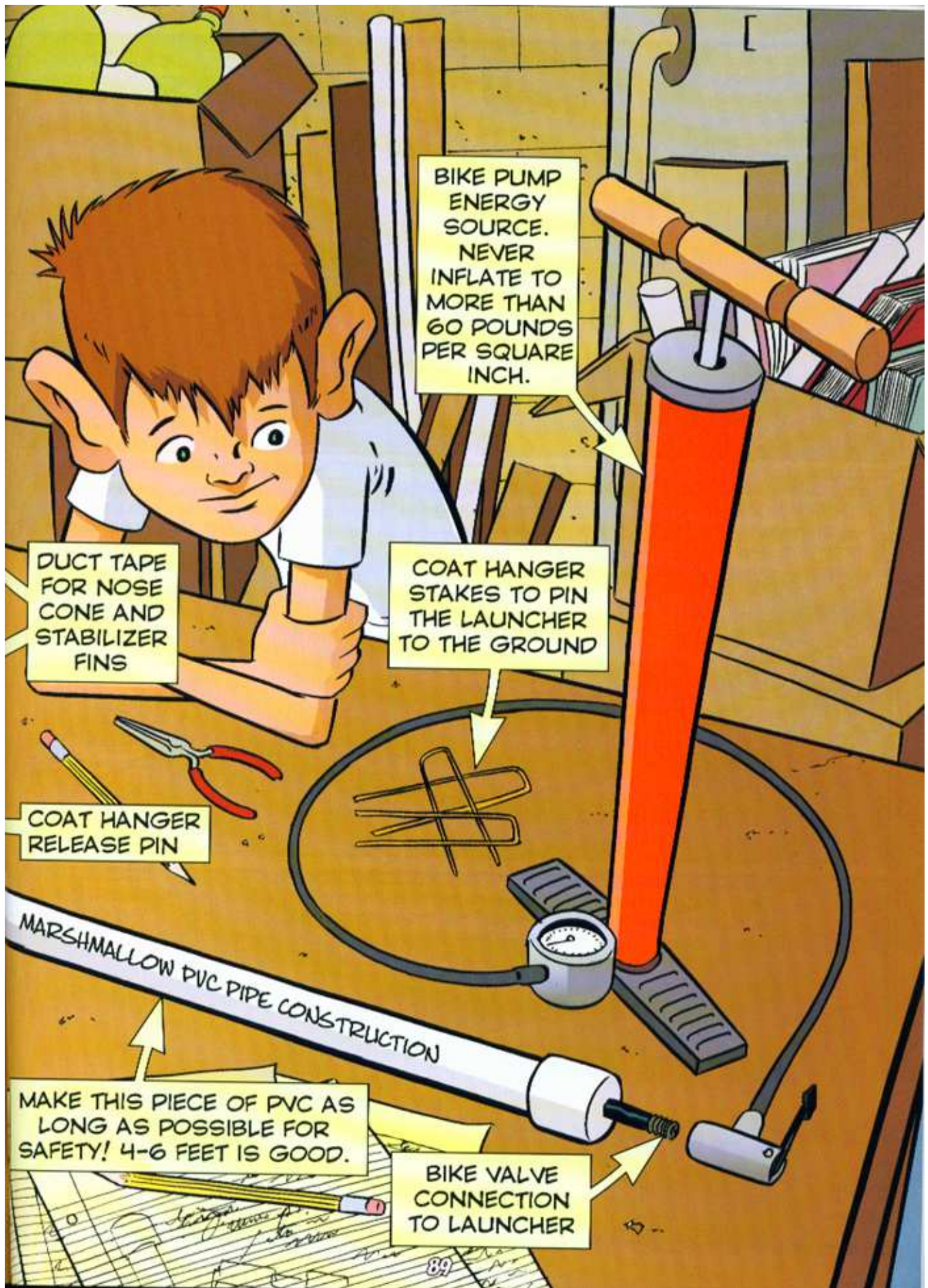
T-BAR GIVES LAUNCHER STABILITY

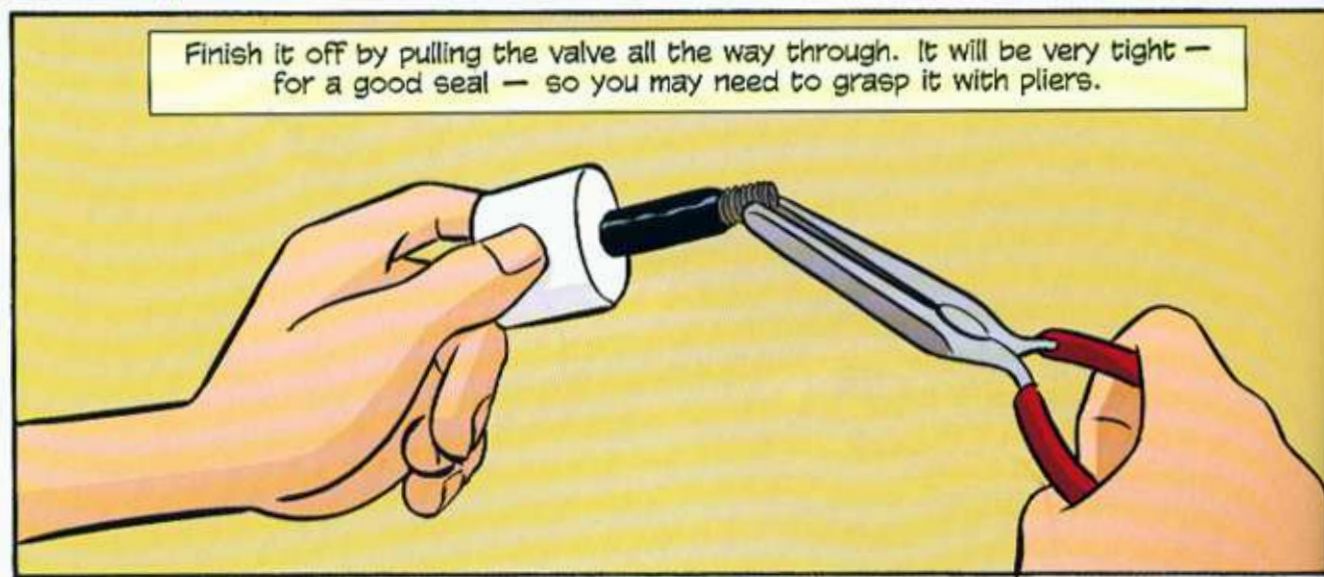
12" PVC PIPE

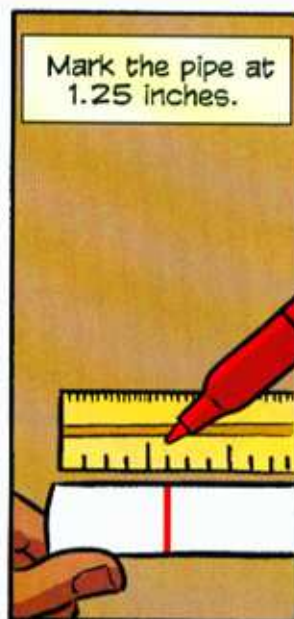
10" PVC PIPE

1/2" PVC END CAP

STRING FOR PULLING RELEASE PIN AT SAFE DISTANCE







Now that the subcomponents are ready, it is time for assembly.



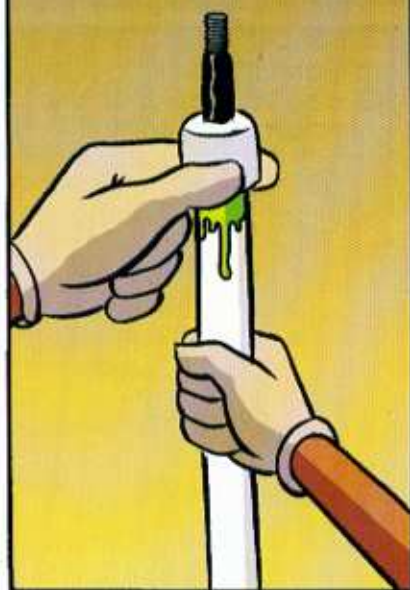
You will need PVC glue, which is toxic! So be sure to apply the glue in a place with good ventilation so you don't breathe the fumes.

Wear rubber gloves, and get the assistance of an adult in handling it.

Paint the glue around the pipe at each joint — do them one at a time.



Place the valve assembly on firmly.

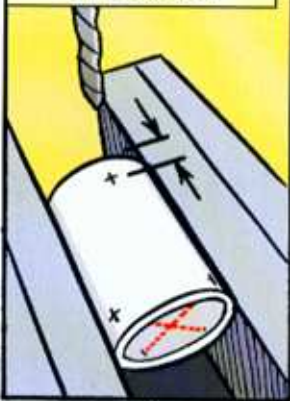


Glue the remaining T-joints and end caps.





With the same 5/16" drill bit, drill two holes in one end of the 1" connector...



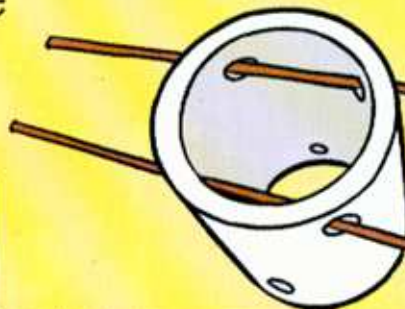
...and four holes in the other end.



Cut an 8" length of coat hanger and bend it halfway around a piece of 1/2" pipe.

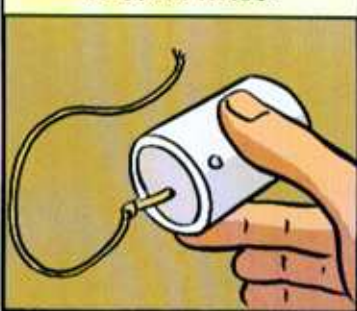


The coat hanger will sit through the four holes like this and grip the top lip of the bottle.



Tie your release string to the coat hanger here...

Finally, we need to attach this release mechanism to the main body of the launcher — Start by tying one end of a piece of string through one of the bottom holes.



Slide it onto the launch tube.

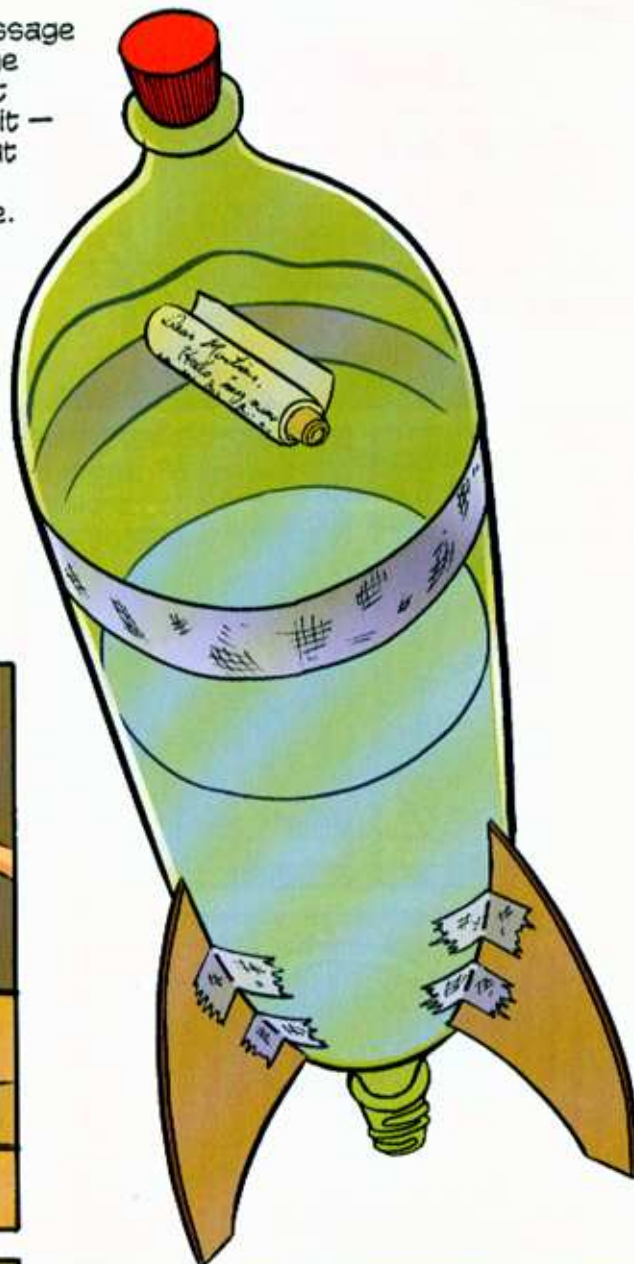


Wrap the string under and tie it through the hole on the other side.

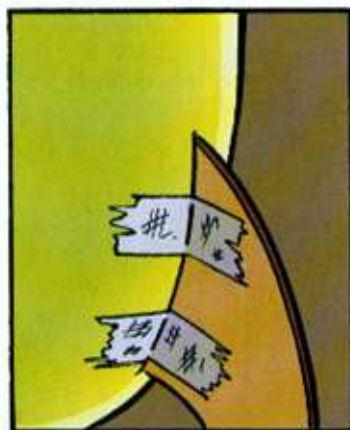


And of course the last thing you'll need is a rocket!

You can leave a message in your bottle for the aliens who will find it once it reaches orbit — or you can figure out a way to pack a parachute in there.

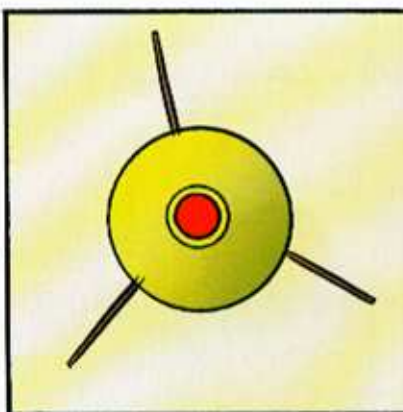


For the fins, cut some fin shapes from cardboard...

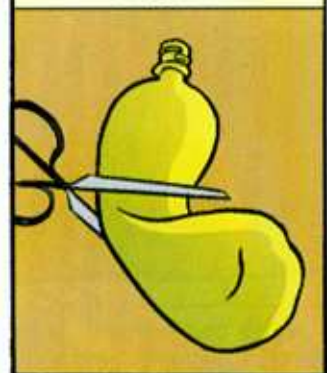


...and tape them firmly to the outside of the bottle.

The stabilizing fins should be symmetrical and aligned with the flight direction!



For the aerodynamic nose cone, cut the top off a second bottle...

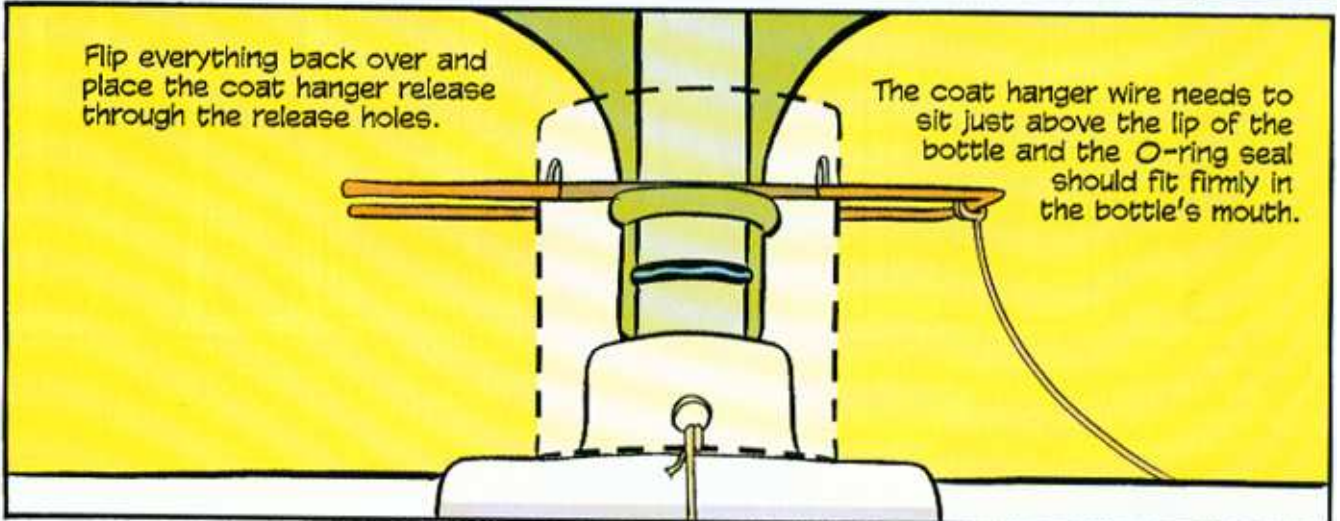


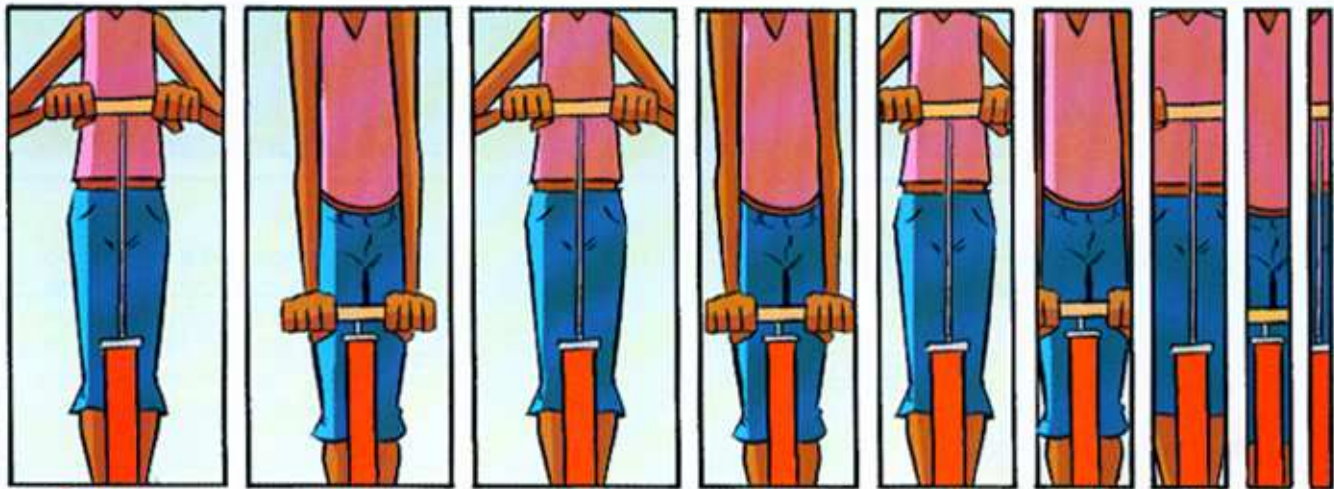
And tape it around the bottom of the main bottle.



And after all that work, we can finally fill the rocket with the power source — plain tap water will do.





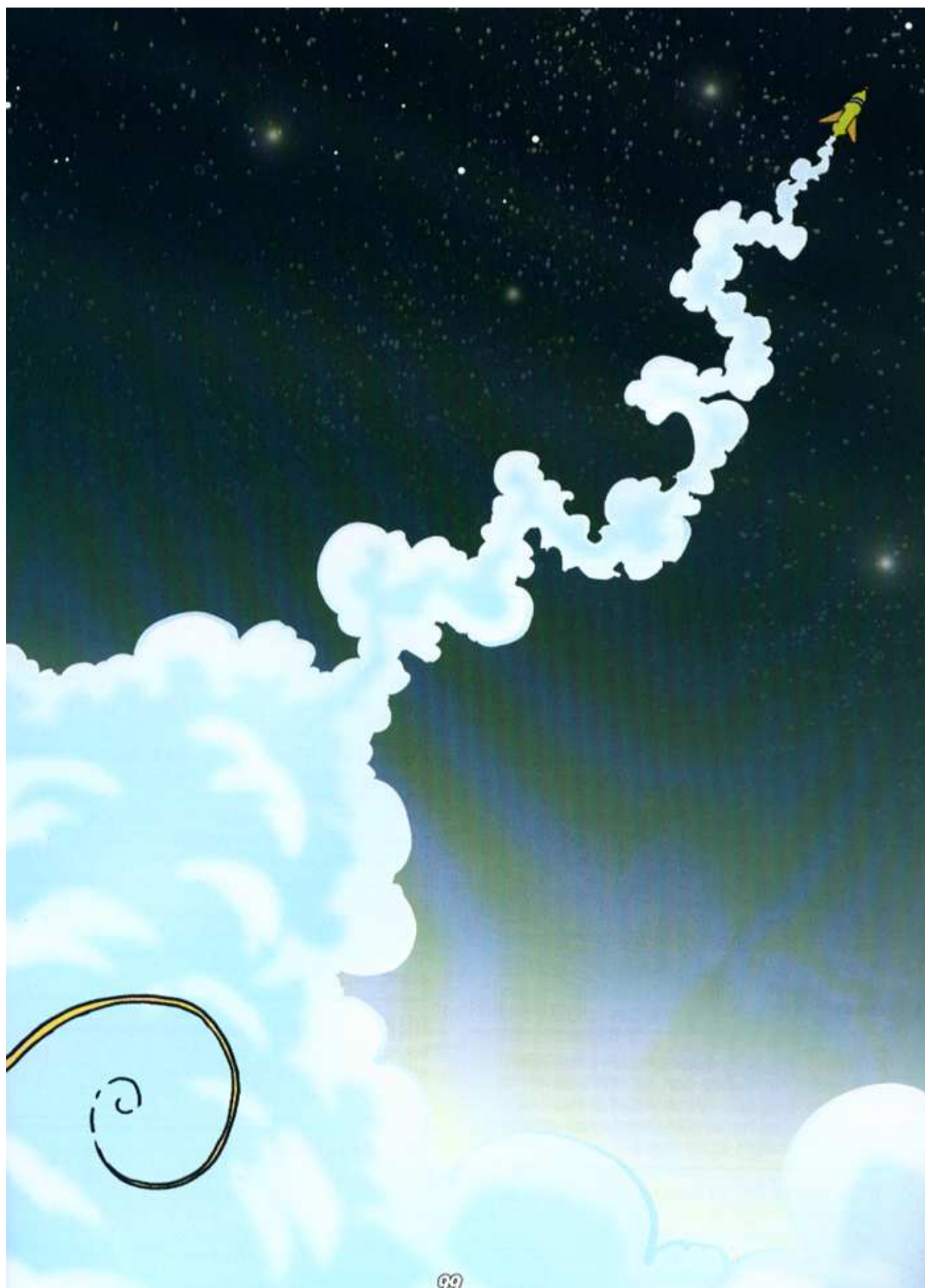


STAND A SAFE DISTANCE BACK, AT LEAST 10 FEET. NEVER, EVER, PUT YOUR BODY OVER THE BOTTLE ONCE YOU'VE STARTED PUMPING, AND REMEMBER—WHAT GOES UP MUST COME DOWN.









GLOSSARY

AERODYNAMICS: This is the study of the way objects move through gases such as air. An object can be considered highly aerodynamic if it meets with little resistance, or "drag," as it moves through the air.

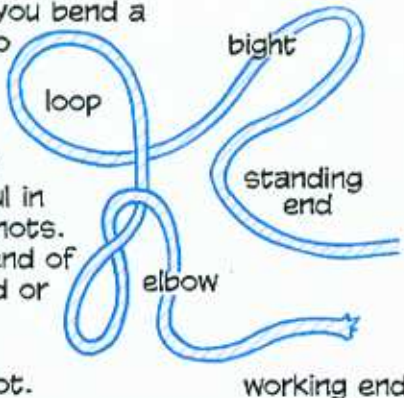
ARBORIST: Also known as a tree surgeon. They are lucky people who get to climb trees all day and care for them. Kind of like vets for plants.

ARMATURE: The rotating coil in electric motors and generators. In our motor, it's the 10 loops of copper wound around the battery.

BASSO: A deep, low singing voice.

BEND: A knot tying two lines (ropes) together.

BIGHT: When you bend a piece of rope to make a knot, it is called a bight. This U-shaped section of rope is useful in forming many knots. Threading the end of the rope around or through the bight is what creates the knot.



BINARY: Describes a system that has two parts or modes (on or off, black or white, 1 or 0). Binary describes the base 2 counting system employed at the heart of modern computers.

BIT: This is the fundamental unit of computation as we know it. It is the name for the 1, or the 0, in binary digits.

BOOB TUBE: This is an antiquated, derogatory term that the artist's mother used to describe a television to those who watched it too much.



BRAID: Three or more things can be interwoven into a braid. Ropes and hair are often braided, but rarely together!



BYTE: 8 bits in a row are called a byte. 00100001 is a byte that represents 132.

CENTIMETER: 1/100th of a meter. It is a commonly used unit in metric measurement. There are 2.54 centimeters in one inch.

COMMUTATOR: The device that switches the direction of current in the armature of an electric motor so that it always goes one way.

CONDUCT: This term is used in science to describe movement through things. Heat conduction describes the movement of heat through a material. Electrical conduction is the movement of charge (or current) through a material.

CURRENT: In the same way that current describes the flow of water in a river, it describes the flow of charge in an electric circuit.

DRAINAGE: The process of draining the liquid from something. Allowing the water to flow to the bottom of your terrarium is drainage for the soil on top.

ECOSYSTEM: In ecology, an ecosystem describes all the living and non-living things in an area. The bacteria and dust in your navel (or belly button) might be described as its own ecosystem.

EMBOUCHURE: The shaping of the lips and movement of face muscles required to make wind instruments work.



FOOT: 12 inches long, or $12 \times 2.54 = 30.48$ centimeters. Very few people have feet that are a foot long.

FOSSIL RECORD:

In the layers of earth beneath us lie the amoeba plants and dinosaurs that used to live on Earth.

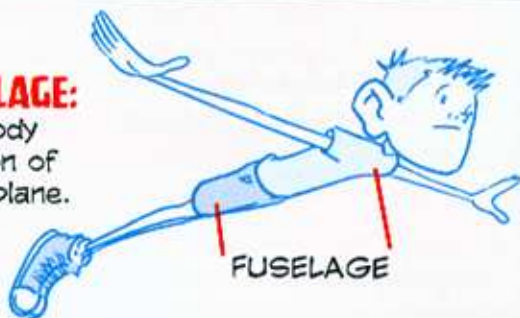
The order of the layers tells us much about our origins. The fossil record resembles a layered cake of history, with the oldest layer on the bottom.



FREEZING POINT: This is the temperature at which a liquid, such as water, turns into a solid, such as ice.

FUSELAGE:

The body section of an airplane.



GAUGE: A tool for making measurements, like a pressure gauge, or a strain gauge, or a fuel or gas gauge.

GRAVITY: The force between two masses. The earth has a huge mass, which means it has a very strong force that pulls your small mass toward it. This has an unfortunate tendency to make you fall toward the ground.

HESSIAN SACK: Also known as burlap, hessian is a heavy woven fabric made principally from jute and other vegetable fibers.

HITCH: A hitch is any form of knot that ties off to a post or ring.

INCH: $1/12$ th of a foot.

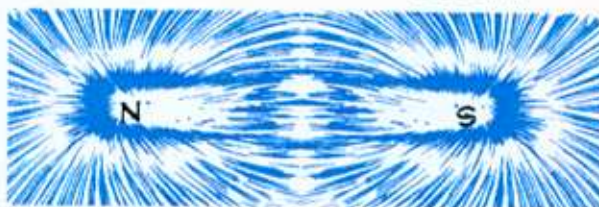
INSULATOR: Thermal insulation slows the flow of heat, while electrical insulation slows the flow of electricity.

LIMERICK: A short and generally humorous poem with a strict format. It's typically five lines long, with an A-A-B-B-A rhyming pattern (this means that the first, second and last lines rhyme with each other, and that the third and fourth lines rhyme with each other).

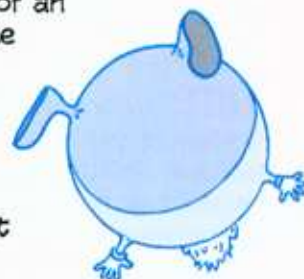
MAGNET: Originally found in Magnesia in Ancient Greece, the word magnet came to describe materials where a magnetic polarity could be stored. The magnetic poles act upon each other to exert force, either attracting or repelling each other.

NORTH

SOUTH



MASS: The mass of an object is kind of like the weight, except that it doesn't change if you move to planets with less gravity, whereas your weight does.



METER: The international standard unit of length. There are 100 centimeters in a meter.

MILLIMETER: 1/1000th of a meter. There are 25.4 mm in an inch. 10mm in 1cm.

NUTRIENTS: A nutrient is food for an organism. The marshmallow in your navel is a nutrient for the bacteria there.

NUTS: Nuts screw onto screws, or bolts. They are often hexagonally shaped donuts with a screw thread in the middle. Like donuts, the right one can be hard to find when you need it.



OCEANOGRAPHY: This is the study of the oceans and the seas of the world. It is becoming increasingly important in terms of understanding global warming and the heating of the oceans. More than 70% of the earth is covered in water; most of it is in the oceans.

PICCOLO: This is a fancy Italian word for a small flute, but can refer to any tiny musical instrument.



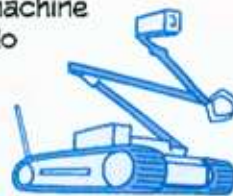
PLANE: Mathematically a plane is a two-dimensional surface, like a sheet of paper. A plain sheet of planar paper can be folded into a paper plane. A three-dimensional paper plane can fly.



POLLUTE: A foreign or toxic item in an ecosystem is a pollutant. Pollution should be avoided. Things like soda bottles should be recycled or reused rather than tossed into the environment where they pollute.

PVC: Polyvinylchloride is the plastic material more commonly known as PVC. It is used a lot in construction, and sometimes in the construction of toys.

ROBOT: A robot is a machine that is programmed to do things. They eat, sleep, and dream in binary.



SAFETY PROTOCOL: A set of guidelines to help you do things safely.

SCOPE: This is the suffix for many technical instruments used to look at or observe something, such as microscopes and telescopes.



SHEARS: The general term for big scissor-type things. Because of their large handles with lots of leverage, they can cut thick things.

SIGN LANGUAGE:

Combines hand shapes and positions into an entire language that is often used by deaf people.



SPLICE: If you braid the end of a piece of rope to the end of a piece of hair, it would be called splicing. Splicing joins two ropes end to end.

SYMMETRICAL: An object is symmetrical, or has symmetry, when it is a reflection through a plane or a rotation around an axis. Your face is mostly symmetrical around the plane of your nose. A soda bottle is symmetrical about the axis that runs from the center of the base to the center of the cap.

THERMODYNAMICS: This is the branch of physics that studies the movement of energy, often in the form of heat, in a system.

VOLTAGE: The measure of the electrical potential of something. The more volts, the more jolts.



WEAVING: Two sets of threads are woven together to create fabric; the process is called weaving. The



warp is the direction the weave comes out of the weaving loom, and the weft is the thread that passes along the length of the loom. You can remember that the weft goes west (if the warp goes north to south!).

WOOD GRAIN: The patterns in a piece of wood caused by the alignment or growth direction of the wood fibers.



YARD: 3 feet or 36 inches long. A yard can also be a great place to play in, and should be many yards long.

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Howtoons: The Possibilities Are Endless

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First Edition



SAUL GRIFFITH grew up in Australia, and his earliest memories of inventing things were of making grappling hooks for climbing trees and buildings. His childhood adventures included making his own rocket-powered toy cars, kites, and enormous puppets. He kept a diary of drawings of his inventions as a kid that included fantastic monorails and airplanes shaped like manta rays. Saul ended up studying materials science—the structure of the materials we use every day—before going on to MIT to do a PhD in building self-replicating machines and a theory for folding 3-dimensional objects. He now works at Squid Labs in California, inventing cool new things for making the world a better place. He still builds kites; they are just much, much bigger now.

NICK DRAGOTTA first knew the power of comic art when he drew injuries on the blackboard at school that were so graphic that his fellow classmates had to leave the room to throw up. Since then he has tirelessly practiced the art of comics and researched the great artists of the field. Nick has drawn for Marvel and DC and is currently passionate about making more comic books for kids. Nick lives in a small apartment with walls lined by the shortened stubs of ruined pencils. He sleeps in a pile of eraser filings, drinks black ink, and exists on a diet of pureed superhero comic books.

JOOST BONSEN immigrated as a young boy to the United States from the Netherlands with his parents and his personal suitcase full of LEGOs. He grew up in Silicon Valley, California, immersed in that creative and entrepreneurial culture. While Joost was growing up, the vacant lot across the street from home served variously as play space, special-effects set, racetrack, rocket launch pad, and more as he and his friends made home movies, practiced being space explorers, and plotted space projects. Joost went to MIT for undergraduate studies in bioelectrical engineering and recently finished his graduate degree at the MIT Sloan School of Management, studying how labs are run, how research themes emerge, and how new technologies are commercialized.



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